



FABENS AIRPORT

HANGAR EXPANSION

EL PASO COUNTY, TEXAS

PROPOSAL

VOLUME II of II (SPECIFICATIONS)

SPECIFICATIONS ADOPTED BY THE TEXAS DEPARTMENT OF TRANSPORTATION, NOVEMBER 1, 2014 AND SPECIFICATION ITEMS LISTED AND DATED AS FOLLOWS, SHALL GOVERN ON THIS PROJECT: REQUIRED CONTRACT PROVISIONS FOR ALL FEDERAL-AID CONSTRUCTION CONTRACTS (FORM FHWA 1273, OCTOBER 2023)

Camino Real Regional Mobility Authority
801 Texas Avenue
El Paso, Texas 79901



PROPOSAL VOLUME II OF II

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A. LIST OF GOVERNING SPECIFICATIONS AND SPECIAL PROVISIONS

FABENS AIRPORT ENTYR SIGNAGE
AIRPORT: FABENS AIRPORT - E35
COUNTY: El Paso

**TEXAS DEPARTMENT OF TRANSPORTATION GOVERNING
SPECIFICATIONS AND SPECIAL PROVISIONS**

ALL SPECIFICATIONS AND SPECIAL PROVISIONS APPLICABLE TO THIS
PROJECT ARE IDENTIFIED AS FOLLOWS:

STANDARD SPECIFICATIONS: ADOPTED BY THE TEXAS DEPARTMENT OF
----- TRANSPORTATION NOVEMBER 1, 2014.
STANDARD SPECIFICATIONS ARE
INCORPORATED INTO THE CONTRACT BY
REFERENCE.

ITEMS 1L TO 9L INCL., GENERAL REQUIREMENTS AND COVENANTS
ITEM 100 PREPARING RIGHT OF WAY (103)
ITEM 105 REMOVING TREATED AND UNTREATED BASE AND ASPHALT PAVMENT
ITEM 110 EXCAVATION (132)
ITEM 132 EMBANKMENT (100) (160) (204) (216) (260) (400)
ITEM 150 BLADING
ITEM 216 PROOF ROLLING (210)
ITEM 247 FLEXIBLE BASE (105) (204) (210) (216) (520)
ITEM 314 EMULSIFIED ASPHALT TREATMENT (204) (300) (3096)
ITEM 320 EQUIPMENT FOR ASPHALT CONCRETE PAVEMNT
ITEM 360 CONCRETE PAVEMENT (421) (422) (438) (440) (529) (585)
ITEM 400 EXCAVATION AND BACKFILL FOR STRUCTURES (110) (132) (401)
(402) (403) (416) (420) (421) (423)
ITEM 402 TRENCH EXCAVATION PROTECTION
ITEM 432 RIPRAP (247) (420) (421) (431) (440)
ITEM 500 MOBILIZAATION
ITEM 502 BARRICADES, SIGNS, AND TRAFFIC HANDLING
ITEM 506 TEMPORARY EROSION, SEDIMENTATION, AND ENVIRONMENTAL
CONTROLS (161) (432) (556)
ITEM 530 INTERSECTIONS, DRIVEWAYS, AND TURNOUTS (247) (260) (263)
(275) (276) (292) (316) (330) (334) (340) (341) (360) (421)
(440) (3076)
ITEM 531 SIDEWALKS (104) (360) (420) (421) (440) (530)
ITEM 550 CHAIN LINK FENCE (421) (445)
ITEM 644 SMALL ROADSIDE SIGN ASSEMBLIES (421) (440) (441) (442) (445)
(636) (643) (656)
ITEM 666 RETROREFLECTORIZED PAVEMENT MARKINGS (316) (502) (662) (677)
(678) (6438)

REQUIRED CONTRACT PROVISIONS, FEDERAL-AID CONSTRUCTION
CONTRACTS (FORM FHWA 1273, OCTOBER 23, 2023)

WAGE RATES

EFFECTIVE January 6, 2023

TXDOT SPECIAL PROVISIONS: SPECIAL PROVISIONS WILL GOVERN AND TAKE
----- PRECEDENCE OVER THE SPECIFICATIONS ENUMERATED
HEREON WHEREVER IN CONFLICT THEREWITH.

SPECIAL PROVISION "NONDISCRIMINATION" (000-002L)
SPECIAL PROVISION "CERTIFICATION OF NONDISCRIMINATION IN EMPLOYMENT
(000-003L)
SPECIAL PROVISION "NOTICE OF REQUIREMENT FOR AFFIRMATIVE ACTION TO
ENSURE EQUAL EMPLOYMENT OPPORTUNITY) (000-004L)
SPECIAL PROVISION "STANDARD FEDERAL EQUAL EMPLOYMENT OPPORTUNITY
CONSTRUCTION CONTRACT SPECIFICATIONS (EXECUTIVE
ORDER 11246)" (000-005L)
SPECIAL PROVISION "CARGO PREFERENCE ACT REQUIREMENTS IN FEDERAL AID
CONTRACTS" (000-0241L)
SPECIAL PROVISION "DISADVANTAGED BUSINESS ENTERPRISE IN FEDERAL AID
CONTRACTS" (000-394L)
SPECIAL PROVISION "SCHEDULE OF LIQUIDATED DAMAGES" (000-1243L)
SPECIAL PROVISION "INSTRUCTIONS TO BIDDERS" (002-009L)
SPECIAL PROVISION "CONTROL OF MATERIALS" (006-030L)
SPECIAL PROVISION "LEGAL RELATIONS AND RESPONSIBILITIES" (007-011L)
SPECIAL PROVISION "MEASUREMENT AND PAYMENT" (009-011L)
SPECIAL PROVISION "TEMPORARY EROSION, SEDIMENTATION, AND
ENVIRONMENTAL CONTROLS" (506-001L)

SPECIAL PROVISION TO ITEM 132 (132-002)
SPECIAL PROVISION TO ITEM 247 (247-003)
SPECIAL PROVISION TO ITEM 314 (314-001)
SPECIAL PROVISION TO ITEM 360 (360-001)
SPECIAL PROVISION TO ITEM 500 (500-008)
SPECIAL PROVISION TO ITEM 502 (502-008)
SPECIAL PROVISION TO ITEM 506 (506-005)
SPECIAL PROVISION TO ITEM 666 (666-007)

CRRMA SPECIAL PROVISIONS: SPECIAL PROVISIONS WILL GOVERN AND TAKE
----- PRECEDENCE OVER THE SPECIFICATIONS ENUMERATED
HEREON WHEREVER IN CONFLICT THEREWITH.

SPECIAL PROVISION "IMPORTANT NOTICE TO CONTRACTORS" (000-ELP1)

TXDOT SPECIAL SPECIFICATIONS:

ITEM 1005 LOOSE AGGREGATE FOR GROUND COVER
ITEM 3076 DENSE-GRADED HOT-MIX ASPHALT (300) (301) (316) (320) (340)
(341) (342) (347) (348) (520) (585) (3079) (3081) (3082)
(3096)

ITEM 5008 WHEEL STOPS
ITEM 6001 PORTABLE CHANGEABLE MESSAGE SIGN
ITEM 6185 TRUCK MOUNTED ATTENUATOR (TMA) AND TRAILER ATTENUATOR (TA)
ITEM 6240 TELECOMMUNICATION SYSTEM
ITEM 7017 SANITARY SEWER
ITEM 7032 WATER MAINS AND SERVICE LINES
ITEM 7049 WATER MAIN
ITEM 7300 WATER MAIN RELOCATION

DATA COLLECTION FOR PAVEMENT MARKINGS

CRRMA SPECIAL SPECIFICATIONS:

ITEM RMA1 SPECIAL CONTRUCTION 270 PRE-ENGINEERED STEEL BUILDING,
FRAME & ROOF ASSEMBLY, MATERIAL & ERECTION (INCLUDING
HANGAR DOOR)
ITEM RMA1 TENANT IMPROVEMENTS
ITEM RMA1 TENANT IMPROVEMENTS (CLASSROOM)
ITEM RMA1 TENANT IMPROVEMENTS (CLASSROOM)
ITEM RMA2 EL PASO COUNTY COPPER SIGNS
ITEM RMA2 REBAR
ITEM RMA2 WWF
ITEM RMA3 SLAB-ON-GROUND
ITEM RMA3 STRIP FOOTING
ITEM RMA3 SPREAD FOOTING
ITEM RMA3 SLAB-ON-DECK
ITEM RMA4 HSS COLUMNS
ITEM RMA4 W18X35
ITEM RMA5 COMPOSITE DECK
ITEM RMA6 METAL PAN STAIRS
ITEM RMA7 RAILING
ITEM RMA8 AIRCRAFT HANGAR
ITEM RMA9 TAB-UNITS-1ST
ITEM RMA9 TAB-UNITS-ADDITIONAL
ITEM RMA9 TAB-AIRFLOW
ITEM RMA9 DUCTWORK
ITEM RMA9 VRF SYSTEM-3 TONS
ITEM RMA9 ERV
ITEM RMA9 CONTROLS
ITEM RMA9 PIPING-REFRIGERANT
ITEM RMA9 PIPING-CONDENSATE
ITEM RMA9 HEATERS-HANGAR
ITEM RMA10 FLOOR DRAIN
ITEM RMA10 TRANCH DRAIN
ITEM RMA10 WALL CLEAN OUT
ITEM RMA10 CLEAN OUT ACCESS
ITEM RMA10 HOSE BIBB
ITEM RMA10 WATER HAMMER ARRESTORS
ITEM RMA10 INTERCEPTOR

ITEM RMA10 WATER CLOSET
 ITEM RMA10 LABATORY
 ITEM RMA10 SINK
 ITEM RMA10 JANITOR SINK
 ITEM RMA10 DRINKING FOUNTAIN
 ITEM RMA10 ICE MAKER BOX
 ITEM RMA10 EYEWASH/SHOWER
 ITEM RMA10 HOT WATER TANK
 ITEM RMA10 INSTANTANEOUS TANKLESS WATER HEATER
 ITEM RMA10 FIRE SPRINKLER SYSTEM
 ITEM RMA10 4" SCHEDULE 40 PVC PIPING
 ITEM RMA10 4" SCHEDULE 40 PVC FITTING
 ITEM RMA10 2" TYPE K COPPER PIPING
 ITEM RMA10 2" VALVES AND FITTING
 ITEM RMA11 LED INTERIOR LIGHTING; 265619 FL-LED EXTERIOR LIGHTNING
 ITEM RMA11 WIRING DEVICES
 ITEM RMA11 PANELBOARDS; 262816 FL-ENCLOSED SWITCHES AND CIRCUIT
 BREAKERS
 ITEM RMA11 HANGARS AND SUPPORTS FOR ELECTRICAL SYSTEMS
 ITEM RMA11 GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
 ITEM RMA11 RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS
 ITEM RMA11 LIGHTING CONTROL DEVICES
 ITEM RMA11 LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES
 ITEM RMA11 UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS
 ITEM RMA11 TELECOMMUNICATION AND FIRE ALARM ALLOWANCE
 ITEM RMA11 TAXIWAY LED EXTERIOR LIGHTING (POLE MOUNTED SOLAR
 FIGTURES)
 ITEM RMA11 TAXIWAY LED EXTERIOR LIGHTING (SOLAR POWERED TAXIWAY
 LIGHTING)

GENERAL: THE ABOVE-LISTED SPECIFICATION ITEMS ARE THOSE UNDER WHICH
 ----- PAYMENT IS TO BE MADE. THESE, TOGETHER WITH SUCH OTHER
 PERTINENT ITEMS, IF ANY, AS MAY BE REFERRED TO IN THE ABOVE LISTED
 SPECIFICATION ITEMS, AND INCLUDING THE SPECIAL PROVISIONS LISTED
 ABOVE, CONSTITUTE THE COMPLETE SPECIFICATIONS FOR THIS PROJECT.

**B. LOCAL GOVERNMENT GENERAL REQUIREMENTS AND
COVENANTS ITEM 1L THRU 9L**

Items 1L–9L

Local Government General Requirements and Covenants

Item 1L

Abbreviations and Definitions



1. APPLICABILITY

Wherever the following terms are used in these specifications or other Contract documents, the intent and meaning will be interpreted as shown below.

2. ABBREVIATIONS

AAR	Association of American Railroads
AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
ACPA	American Concrete Pipe Association
AI	Asphalt Institute
AIA	American Institute of Architects
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
AITC	American Institute of Timber Construction
ALSC	American Lumber Standard Committee, Inc.
AMRL	AASHTO Materials Reference Laboratory
ANLA	American Nursery and Landscape Association
ANSI	American National Standards Institute
APA	The Engineered Wood Association
API	American Petroleum Institute
APWA	American Public Works Association
AREMA	American Railway Engineering and Maintenance-of-Way Association
ASBI	American Segmental Bridge Institute
ASCE	American Society of Civil Engineers
ASLA	American Society of Landscape Architects
ASME	American Society of Mechanical Engineers
ASNT	American Society for Nondestructive Testing
ASTM	American Society for Testing and Materials
AWC	American Wood Council
AWG	American Wire Gage
AWPA	American Wood Protection Association
AWPI	American Wood Preservers Institute
AWS	American Welding Society
AWWA	American Water Works Association
BMP	Best Management Practices
CFR	Code of Federal Regulations
CMP	Corrugated Metal Pipe
COE	U.S. Army Corps of Engineers
CRSI	Concrete Reinforcing Steel Institute
DBE	Disadvantaged Business Enterprise
DMS	Departmental Material Specification
EIA	Electronic Industries Alliance
EPA	United States Environmental Protection Agency
FHWA	Federal Highway Administration, U.S. Department of Transportation
FSS	Federal Specifications and Standards (General Services Administration)
GSA	United States General Services Administration
HUB	Historically Underutilized Business
ICEA	Insulated Cable Engineers Association
IEEE	Institute of Electrical and Electronics Engineers

IESNA	Illuminating Engineering Society of North America
IMSA	International Municipal Signal Association
ISO	International Organization for Standardization
ITS	Intelligent Transportation System
ITE	Institute of Transportation Engineers
LG	Local Government
LRFD	Load and Resistance Factor Design
MASH	Manual for Assessing Safety Hardware
MPL	Material Producer List (TxDOT document)
NCHRP	National Cooperative Highway Research Program
NCR	Nonconformance Report (TxDOT form)
NEC	National Electrical Code (Published by NFPA)
NEMA	National Electrical Manufacturers Association
NEPA	National Environmental Policy Act
NESC	National Electrical Safety Code
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
NRM	Nonhazardous Recyclable Material
NRMCA	National Ready Mixed Concrete Association
NSBA	National Steel Bridge Alliance
NTPEP	National Transportation Product Evaluation Program
OSHA	Occupational Safety & Health Administration, U.S. Department of Labor
PCA	Portland Cement Association
PCI	Precast/Prestressed Concrete Institute
PE	Professional Engineer
PPI	Plastics Pipe Institute
PS&E	Plans, Specifications, and Estimates
PSL	Project-Specific Location
PTI	Post-Tension Institute
QA	Quality Assurance
QC	Quality Control
RCP	Reinforced Concrete Pipe
RPLS	Registered Public Land Surveyor
RRC	Railroad Commission of Texas
SBE	Small Business Enterprise
SFPA	Southern Forest Products Association
SI	International System of Units
SPIB	Southern Pine Inspection Bureau
SSPC	The Society for Protective Coatings
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
TDLR	Texas Department of Licensing and Regulation
TGC	Texas Government Code
TMUTCD	Texas Manual on Uniform Traffic Control Devices
TxDOT	Texas Department of Transportation
UL	Underwriters Laboratory, Inc.
USC	United States Code
WRI	Wire Reinforcement Institute
WWPA	Western Wood Products Association

3. DEFINITIONS

Abrasive Blasting. Spraying blasts of pressurized air combined with abrasive media.

Actual Cost. Contractor's actual cost to provide labor, material, equipment, and project overhead necessary for the work.

Addendum. Change in bid documents developed between advertising and bid submittal deadline.

Additive Alternate. A bid item contained in the bid documents that is not a regular item or a replacement alternate bid item. The additive alternate items include work that may be added to the base bid work.

Deductive Alternate. A bid item contained in the bid documents that is not a regular item or a replacement alternate bid item. The deductive alternate items include work that may be deducted from the base bid work.

Advertisement. The public announcement required by law inviting bids for work to be performed or materials to be furnished.

Affiliates. Two or more firms are affiliated if they share common officers, directors, or stockholders; a family member of an officer, director, or stockholder of one firm serves in a similar capacity in another of the firms; an individual who has an interest in, or controls a part of, one firm either directly or indirectly also has an interest in, or controls a part of, another of the firms; the firms are so closely connected or associated that one of the firms, either directly or indirectly, controls or has the power to control another firm; one firm controls or has the power to control another of the firms; or the firms are closely allied through an established course of dealings, including, but not limited to, the lending of financial assistance.

Air Blasting. Spraying blasts of pressurized air free of oil and moisture.

Air Temperature. The temperature measured in degrees Fahrenheit (°F) in the shade, not in the direct rays of the sun, and away from artificial heat.

Anticipated Profit. Profit for work not performed.

Apparent Low Bidder. The Bidder determined to have the numerically lowest total bid as a result of the tabulation of bids by the Owner.

Architect of Record. A person registered as an architect or licensed as a landscape architect, in accordance with State law, exercising overall responsibility for the design or a significant portion of the design and performs certain Contract administration responsibilities as described in the Contract; or a firm employed by the Owner to provide professional architectural services.

Arterial Highway. A highway used primarily for through traffic and usually on a continuous route.

Notice of Award. The Owner's acceptance of a Contractor's bid for a proposed Contract that authorizes the Owner to enter into a Contract.

Base Bid. The total bid amount without additive alternates.

Bid. The offer from the Bidder for performing the work described in the bid documents, submitted on the prescribed bid form, considering addenda issued and giving unit bid prices for performing the work described in the bid documents.

Bid Bond. The security executed by the Contractor and the Surety furnished to the Owner to guarantee payment of liquidated damages if the Contractor fails to enter into an awarded Contract.

Bid Documents. The complete set of documents necessary for a Bidder to submit a bid. The documents may include plans, specifications, special specifications, special provisions, addenda, and the prescribed form a Bidder is to submit as the Bid. Other terms used may include general conditions, proposal, instructions to bidders, and construction specifications.

Bid Error. A mathematical mistake made by a Bidder in the unit price entered into the bid documents.

Bidder. An individual, partnership, limited liability company, corporation, or joint venture submitting a bid for a proposed Contract.

Blast Cleaning. Using one of the blasting methods, including, but not limited to, water blasting, low-pressure water blasting, high-pressure water blasting, abrasive blasting, water-abrasive blasting, shot blasting, slurry blasting, water injected abrasive blasting, and brush blasting.

Bridge. A structure, including supports, erected over a depression or an obstruction (e.g., water, a highway, or a railway) having a roadway or track for carrying traffic or other moving loads, and having an opening measured along the center of the roadway of more than 20 ft. between faces of abutments, spring lines of arches, or extreme ends of the openings for multiple box culverts.

Brush Blasting. Sweeping lightly with an abrasive blast to remove loose material.

Building Contract. A Contract entered under State law for the construction or maintenance of an Owner building or appurtenance facilities. Building Contracts are considered to be construction Contracts.

Certificate of Insurance. A form approved by the Owner covering insurance requirements stated in the Contract.

Change Order. Written order to the Contractor detailing changes to the specified work, item quantities or any other modification to the Contract.

Concrete Construction Joint. A joint formed by placing plastic concrete in direct contact with concrete that has attained its initial set.

Concrete Repair Manual. TxDOT manual specifying methods and procedures for concrete repair as an extension of the standard specifications.

ConcreteWorks®. TxDOT-owned software for concrete heat analysis. Software is available on the TxDOT's website.

Construction Contract. A Contract entered under State law for the construction, reconstruction, or maintenance of a segment of the Owner's transportation system.

Consultant. The licensed professional engineer or engineering firm, or the architect or architectural firm, registered in the State of Texas and under Contract to the Owner to perform professional services. The consultant may be the Engineer or architect of record or may provide services through and be subcontracted to the Engineer or architect of record.

Contract. The agreement between the Owner and the Contractor establishing the obligations of the parties for furnishing of materials and performance of the work prescribed in the Contract documents.

Contract Documents. Elements of the Contract, including, but not limited to, the plans, specifications incorporated by reference, special provisions, special specifications, Contract bonds, change orders, addendums, and supplemental agreements.

Contract Time. The number of days specified for completion of the work, including authorized additional working days.

Contractor. The individual, partnership, limited liability company, corporation, or joint venture and all principals and representatives with which the Contract is made by the Owner.

Controlled Access Highway. Any highway to or from which access is denied or controlled, in whole or in part, from or to abutting land or intersecting streets, roads, highways, alleys, or other public or private ways.

Control of Access. The condition in which the right to access of owners or occupants of abutting land or other persons in connection with a highway is fully or partially controlled by public authority.

Control Point. An established point shown on the plans to provide vertical and horizontal references for geometric control for construction.

Cross-Sections. Graphic representations of the original ground and the proposed facility, at right angles to the centerline or base line.

Culvert. Any buried structure providing an opening under a roadway for drainage or other purposes. Culverts may also be classified as bridges. (See Section 1.3.23., "Bridge.")

Cycle. The activity necessary for performing the specified work within the right of way project limits once.

Daily Road-User Cost. Damages based on the estimated daily cost of inconvenience to the traveling public resulting from the work.

Date of Written Authorization. Date of the written Notice to Proceed authorizing the Contractor to begin work.

Debar (Debarment). Action taken by the Owner, State, or federal government pursuant to regulation that prohibits a person or company from entering into a Contract, or from participating as a subcontractor, or supplier of materials or equipment used in a highway improvement Contract as defined in local, state, or federal law.

Detour. A temporary traffic route around a closed portion of a road.

Department. When used in the context of the party with whom the Contractor has a Construction Contract, Department refers to Owner. When used in other contexts such as technical specifications, refers to the Texas Department of Transportation.

Departmental Material Specifications. Reference specifications for various materials published by TxDOT's Construction Division with a DMS-XXXXXX numbering system.

Direct Traffic Culvert. Concrete box culvert whose top slab is used as the final riding surface or is to have an overlay or other riding surface treatment.

Disadvantaged Business Enterprise. A small business certified through the Texas Unified Certification Program in accordance with 49 CFR Part 26, that is at least 51% owned by one or more socially and economically disadvantaged individuals, or in the case of a publicly owned business, in which is at least 51% of the stock is owned by one or more socially and economically disadvantaged individuals, and whose management and daily business operations are controlled by one or more of the individuals who own it.

Divided Highway. A highway with separate roadways intended to move traffic in opposite directions.

Easement. A real property right acquired by one party to use land belonging to another party for a specified purpose.

Engineer. The Professional Engineer licensed in Texas who represents the interests of the Owner.

Entity. Political subdivision for which the project is designed and constructed. Either a Municipality (City) or a County or other entity organized under the authority of State of Texas statutes. May also be referred to as an **Owner**.

Expressway. A divided arterial highway for through traffic with full or partial control of access and generally with grade separations at intersections.

Family Member. A family member of an individual is the individual's parent, parent's spouse, step-parent, step-parent's spouse, sibling, sibling's spouse, spouse, child, child's spouse, spouse's child, spouse's child's spouse, grandchild, grandparent, uncle, uncle's spouse, aunt, aunt's spouse, first cousin, or first cousin's spouse.

Force Account. Payment for directed work based on the actual cost of labor, equipment, and materials furnished with markups for project overhead and profit.

Freeway. An expressway with full control of access.

Frontage Road. A local street or road auxiliary to and located along an arterial highway for service to abutting property and adjacent areas and for control of access (sometimes known as a service road, access road, or insulator road).

Hazardous Materials or Waste. Hazardous materials or waste include, but are not limited to, explosives, compressed gas, flammable liquids, flammable solids, combustible liquids, oxidizers, poisons, radioactive materials, corrosives, etiologic agents, and other material classified as hazardous by 40 CFR 261, or applicable state and federal regulations.

High-Pressure Water Blasting. Water blasting with pressures between 5,000 and 10,000 psi.

Highway, Street, or Road. General terms denoting a public way for purposes of vehicular travel, including the entire area within the right of way. Recommended usage in urban areas is highway or street; in rural areas, highway or road.

Historically Underutilized Business. A corporation, sole proprietorship, partnership, or joint venture formed for the purpose of making a profit certified by the Texas Comptroller of Public Accounts, and 51% owned by one or more persons who are economically disadvantaged because of their identification as members of certain groups, including African Americans, Hispanic Americans, Asian-Pacific Americans, Native Americans, or women, and have a proportionate interest and demonstrate active participation in the control, operation, and management of the business' affairs. Individuals meeting the HUB definition are required to be residents of the State of Texas. Businesses that do not have their primary headquarters in the State of Texas are not eligible for HUB certification.

Incentive/Disincentive Provisions. An adjustment to the Contract price of a predetermined amount for each day the work is completed ahead of or behind the specified milestone, phase, or Contract completion dates. The amount of the incentive/disincentive is determined based on estimated costs for engineering, traffic control, delays to the motorists, and other items involved in the Contract.

Independent Assurance Tests. Tests used to evaluate the sampling and testing techniques and equipment used in the acceptance program. The tests are performed by the Owner or the Owner's representative and are not used for acceptance purposes.

Inspector. The person assigned by the Owner to inspect any or all parts of the work and the materials used for compliance with the Contract.

Intelligent Transportation System. An integrated system that uses video and other electronic detection devices to monitor traffic flows.

Intersection. The general area where 2 or more highways, streets, or roads join or cross, including the roadway and roadside facilities for traffic movements within it.

Island. An area within a roadway from which vehicular traffic is intended to be excluded, together with any area at the approach occupied by protective deflecting or warning devices.

Joint Venture. Any combination of individuals, partnerships, limited liability companies, or corporations submitting a single bid form.

Lane Rental. A method to assess the Contractor daily or hourly rental fees for each lane, shoulder, or combination of lanes and shoulders taken out of service.

Letting. The receipt, opening, tabulation, and determination of the apparent low Bidder.

Letting Official. The Owner representative empowered by the Owner to officially receive bids and close the receipt of bids at a letting.

Licensed Professional Engineer. A person who has been duly licensed by the Texas Board of Professional Engineers to engage in the practice of engineering in the State of Texas; also referred to as a Professional Engineer.

Limits of Construction. An area with established boundaries, identified within the highway right of way and easements, where the Contractor is permitted to perform the work.

Local Street or Road. A street or road primarily for access to residence, business, or other abutting property.

Low-Pressure Water Blasting. Water blasting with pressures between 3,000 and 5,000 psi.

Major Item. An item of work included in the Contract that has a total cost equal to or greater than 5% of the original Contract or \$100,000 whichever is less. A major item at the time of bid will remain a major item. An item not originally a major item does not become one through the course of the Contract.

Manual of Testing Procedures. Department manual outlining test methods and procedures maintained by the Materials and Tests Division.

Material Producer List. TxDOT-maintained list of approved products. Referenced as "Department's MPL".

Materially Unbalanced Bid. A bid that generates a reasonable doubt that award to the Bidder submitting a mathematically unbalanced bid will result in the lowest ultimate cost to the Owner.

Mathematically Unbalanced Bid. A bid containing bid prices that do not reflect reasonable actual costs plus a reasonable proportionate share of the Bidder's anticipated profit, overhead costs, and other indirect costs.

Median. The portion of a divided highway separating the traffic lanes in opposite directions.

Milestone Date. The date that a specific portion of the work is to be completed, before the completion date for all work under the Contract.

Monolithic Concrete Placement. The placement of plastic concrete in such manner and sequence to prevent a construction joint.

National Holidays. January 1, the last Monday in May, July 4, the first Monday in September, the fourth Thursday in November, and December 24 or December 25.

Nonhazardous Recyclable Material. A material recovered or diverted from the nonhazardous waste stream for the purposes of reuse or recycling in the manufacture of products that may otherwise be produced using raw or virgin materials.

Nonresident Bidder. A Bidder whose principal place of business is not in Texas. This includes a Bidder whose ultimate parent company or majority owner does not have its principal place of business in Texas.

Nonresponsive Bid. A bid that does not meet the criteria for acceptance contained in the bid documents.

Non-Site-Specific Contracts. Contracts in which a geographic region is specified for the work and for which work orders, with or without plans, further detail the limits and work to be performed.

Notice to Proceed, Written notification to the Contractor authorizing work to begin.

Notification. Either written or oral instruction to the Contractor concerning the work. Voice mail is oral notification.

Owner, Political subdivision for whom the project is designed and constructed. Either a Municipality (City), a County or other entity organized under the authority of State of Texas statutes. May also be referred to as an **Entity**.

Pavement. That part of the roadway having a constructed surface for the use of vehicular traffic.

Pavement Structure. Combination of surface course and base course placed on a subgrade to support the traffic load and distribute it to the roadbed.

2.1.1. **Surface Course.** Pavement structure layers designed to accommodate the traffic load. The top layer resists skidding, traffic abrasion, and the disintegrating effects of climate and is sometimes called the wearing course.

2.1.2. **Base Course.** One or more layers of specified material thickness placed on a subgrade to support a surface course.

2.1.3. **Subgrade.** The top surface of a roadbed upon which the pavement structure, shoulders, and curbs are constructed.

2.1.4. **Subgrade Treatment.** Modifying or stabilizing material in the subgrade.

Payment Bond. The security executed by the Contractor and the Surety, furnished to the Owner to guarantee payment of all legal debts of the Contractor pertaining to the Contract.

Performance Bond. The security executed by the Contractor and the Surety, furnished to the Owner to guarantee the completion of the work in accordance with the terms of the Contract.

Plans. The approved drawings, including true reproductions of the drawings that show the location, character, dimensions, and details of the work and are a part of the Contract.

Power of Attorney for Surety Bonds. An instrument under corporate seal appointing an attorney-in-fact to act on behalf of a Surety in signing bonds.

Qualification. The process for determining a Contractor's eligibility to be awarded a construction contract

Prequalification. The process for determining a Contractor's eligibility to bid work.

Prequalification Statement. The forms on which required information is furnished concerning the Contractor's ability to perform and finance the work.

Prequalified Contractor. A contractor that is approved to bid on TxDOT contracts by satisfying their Prequalification Process.

Post Qualification. The owner will determine if contractors are qualified to bid on the project after bids are open. The bid documents will identify the minimum requirements that contractor must meet to be qualified for the project. Unqualified contractors' bids will be considered non-responsive and not accepted.

Project-Specific Location. A material source, plant, waste site, parking area, storage area, field office, staging area, haul road, or other similar location either outside the project limits or within the project limits but not specifically addressed in the Contract.

Proposal. The offer from the Bidder submitted on the prescribed form, including addenda issued, giving unit bid prices for performing the work described in the plans and Specifications.

Proposal Form. The form printed and sent to the Bidder by the Owner or printed by the Bidder from the Owner's bidding system.

Proposal Guaranty. The security furnished by the Bidder as a guarantee that the Bidder will enter into a Contract if awarded the work.

Quality Assurance. Sampling, testing, inspection, and other activities conducted by the Engineer to determine payment and make acceptance decisions.

Quality Control. Sampling, testing, and other process control activities conducted by the Contractor to monitor production and placement operations.

Ramp. A section of highway for the primary purpose of making connections with other highways.

Referee Tests. Tests requested to resolve differences between Contractor and Owner test results. The referee laboratory is the Owners.

Regular Item. A bid item contained in the bid documents and not designated as an additive alternate or replacement alternate bid item.

Rental Rate Blue Book for Construction Equipment. Publication containing equipment rental rates.

Replacement Alternate. A bid item identified on the bid documents that a Bidder may substitute for a specific regular item of work.

Responsive Bid. A bid that meets all requirements of the advertisement and the bid documents for acceptance.

Right of Way. A general term denoting land or property devoted to transportation purposes.

Roadbed. The graded portion of a highway prepared as foundation for the pavement structure and shoulders. On divided highways, the depressed median type and the raised median type highways are considered to have 2 roadbeds. Highways with a flush median are considered to have 1 roadbed. Frontage roads are considered separate roadbeds.

Road Master. A railroad maintenance official in charge of a division of railway.

Roadside. The areas between the outside edges of the shoulders and the right of way boundaries. Unpaved median areas between inside shoulders of divided highways and areas within interchanges are included.

Roadway. The portion of the highway (including shoulders) used by the traveling public.

Sandblasting, Dry. Spraying blasts of pressurized air combined with sand.

Sandblasting, Wet. Spraying blasts of pressurized water combined with sand.

Shoulder. That portion of the roadway contiguous with the traffic lanes for accommodation of stopped vehicles for emergency use or for lateral support of base and surface courses.

Shot Blasting. Spraying blasts of pressurized air combined with metal shot.

Sidewalk. Portion of the right of way constructed exclusively for pedestrian use.

Slurry Blasting. Spraying blasts of pressurized air combined with a mixture of water and abrasive media.

Special Provisions. Additions or revisions to these standard specifications or special specifications.

Special Specifications. Supplemental specifications applicable to the Contract not covered by these standard specifications.

Specifications. Directives or requirements issued or made pertaining to the method and manner of performing the work or to quantities and qualities of materials to be furnished under the Contract. References to DMSs, ASTM or AASHTO specifications, or TxDOT bulletins and manuals, imply the latest standard or tentative standard in effect on the date of the bid. The Owner will consider incorporation of subsequent changes to these documents in accordance with Item 4L, "Scope of Work."

Small Business Enterprise. A firm (including affiliates) whose annual gross receipts do not exceed the U.S. Small Business Administration's size standards for 4 consecutive years.

State. The State of Texas.

State Holiday. A holiday authorized by the State Legislature excluding optional state holidays and not listed in Section 1L.3.85., "National Holidays." A list of state holidays can be found on the TxDOT's website.

Station. A unit of measurement consisting of 100 horizontal feet.

Subcontract. The agreement between the Contractor and subcontractor establishing the obligations of the parties for furnishing of materials and performance of the work prescribed in the Contract documents.

Subcontractor. An individual, partnership, limited liability company, corporation, or any combination thereof that the Contractor sublets, or proposes to sublet, any portion of a Contract, excluding a material supplier, a hauling firm hauling only from a commercial source to the project, truck owner-operator, wholly-owned subsidiary, or specialty-type businesses such as security companies and rental companies.

Subsidiary. Materials, labor, or other elements that because of their nature or quantity have not been identified as a separate item and are included within the items on which they necessarily depend.

Substructure. The part of the structure below the bridge seats, but not including bearings, drilled shafts, or piling. Parapets, back walls, wing walls of the abutments, and drainage structures are considered parts of the substructure.

Superintendent. The representative of the Contractor who is available at all times and able to receive instructions from the Owner or authorized Owner representatives and to act for the Contractor.

Superstructure. The part of the structure above the bridge seats or above the springing lines of arches and including the bearings. Flatwork construction may be considered superstructure.

Supplemental Agreement. Written agreement entered into between the Contractor and the Owner and approved by the Surety, covering alterations and changes in the Contract. A supplemental agreement is used by the Owner whenever the modifications include assignment of the Contract from one party to another or other cases as desired by the Owner.

Surety. The corporate body or bodies authorized to do business in Texas bound with and for the Contractor for the faithful performance of the work covered by the Contract and for the payment for all labor and material supplied in the prosecution of the work.

Surplus Materials. Any debris or material related to the Contract but not incorporated into the work.

Suspension. Action taken by the Owner, State, or federal government pursuant to regulation that prohibits a person or company from entering into a Contract, or from participating as a subcontractor, or supplier of materials or equipment used in a contract

Tex –XXX-X. TxDOT material test methods found on TxDOT's website.

Traffic Lane. The strip of roadway intended to accommodate the forward movement of a single line of vehicles.

Traveled Way. The portion of the roadway for the movement of vehicles, exclusive of shoulders and auxiliary lanes.

Truck Owner-Operator. An individual who owns and operates 1 truck for hire.

UT-Bridge. TxDOT-owned software for steel girder erection. Software is available on TxDOT's website.

UT-Lift. TxDOT-owned software for steel girder erection. Software is available on TxDOT's website.

Utility. Privately, publicly, or cooperatively owned lines, facilities, and systems for producing, transmitting, or distributing communications, power, heat, gas, oil, water, waste, or storm water that are not connected with the highway drainage, signal systems, or other products that directly or indirectly serve the public; the utility company.

Verification Tests. Tests used to verify accuracy of QC and QA and mixture design testing.

Water-Abrasive Blasting. Spraying blasts of pressurized water combined with abrasive media.

Water Blasting. Spraying blasts of pressurized water of at least 3,000 psi.

Water-Injected Abrasive Blasting. Abrasive blasting with water injected into the abrasive/air stream at the nozzle.

Wholly-Owned Subsidiary. A legal entity owned entirely by the Contractor or subcontractor.

Work. The furnishing of all labor, materials, equipment, and other incidentals necessary for the successful completion of the Contract.

Written Notice. Written notice is considered to have been duly given if delivered in person to the individual or member to whom it is intended or if sent by regular, registered, or certified mail and delivered to the last known business address; sent by facsimile to the last known phone number; or sent by e-mail to the last known address. The date of the letter will serve as the beginning day of notice. Unclaimed mail or failure to provide current mailing address will not be considered a failure to provide written notice.

Item 2L

Instructions to Bidders



4. INTRODUCTION

Instructions to the Contractor in these specifications are generally written in active voice, imperative mood. The subject of imperative sentences is understood to be "the Contractor." The Owner's responsibilities are generally written in passive voice, indicative mood. Phrases such as "as approved," "unless otherwise approved," "upon approval," "as directed," "as verified," "as ordered," and "as determined" refer to actions of the Engineer unless otherwise stated, and it is understood that the directions, orders, or instructions to which they relate are within the limitations of and authorized by the Contract.

5. ELIGIBILITY OF BIDDERS

Bidders on this project must be prequalified through TxDOT by meeting the requirements of the Confidential Questionnaire (CQ). Refer to TxDOT's website for prequalification requirements. Assure prequalification documents are submitted to TxDOT at least 14 days before bid opening. Comply with all technical prequalification requirements in the bid documents.

6. ISSUING BID DOCUMENTS

Bid Document information may be obtained at the Camino Real Regional Mobility Authority website <https://www.crrma.org/procurements> or by submitting an email request to: Laura.Nevarez@atkinsrealis.com

At the time Bid Documents are obtained, Bidder must provide a working e-mail address, so as to receive any addenda or clarification issued by the Owner.

The Owner will not issue bid documents if one or more of the following apply:

- the Bidder is suspended or debarred by the Department or federal agency,
- the Bidder has not fulfilled the requirements for prequalification,
- the Bidder is prohibited from rebidding a specific project due to a bid error on the original bid documents,
- the Bidder failed to enter into a Contract on the original award,
- the Bidder was defaulted or terminated on the original Contract, unless the Owner terminated for convenience, or
- the Bidder or a subsidiary or affiliate of the Bidder has received compensation from the Owner to participate in the preparation of the plans or specifications on which the bid or Contract is based.

7. INTERPRETING ESTIMATED QUANTITIES

The quantities listed in the bid documents are approximate and will be used for the comparison of bids. Payments will be made for actual quantities of work performed in accordance with the Contract.

8. EXAMINING DOCUMENTS AND WORK LOCATIONS

Examine the bid documents and specified work locations before submitting a bid for the work. Submitting a bid will be considered evidence that the Bidder has performed this examination. Borings, soil profiles, water elevations, and underground utilities shown on the plans were obtained for the use of the Owner in the preparation of plans. This information is provided for the Bidder's information only and the Owner makes no representation as to the accuracy of the data. Be aware of the difficulty of accurately classifying all material

encountered in making foundation investigations, the possible erosion of stream channels and banks after survey data have been obtained, and the unreliability of water elevations other than for the date recorded.

Oral explanations, instructions, or consideration for Contractor-proposed changes in the bid documents given during the bidding process are not binding. Only requirements included in the bid documents and Owner-issued addenda are binding. Request explanations of documents at least five(5) days prior to the bid opening.

Immediately notify the Owner of any error, omission, or ambiguity discovered in any part of the bid documents. The Owner will issue addenda when appropriate.

9. PREPARING THE BID

Prepare the proposal form furnished by the Owner. Informational proposal forms printed from the Owner's website will not be accepted.

Specify a unit price in dollars and cents for each regular item, additive alternate item, deductive alternate item or replacement alternate item for which an estimated quantity is given.

When "Working Days" is an item, submit the number of working days to be used to complete the Contract or phases of the Contract.

The Owner will not accept an incomplete bid. A bid that has one or more of the deficiencies listed below is considered incomplete:

- the proposal form was not signed,
- all certifications were not acknowledged,
- a regular item, additive alternate item or deductive alternate item is left blank,
- a regular item and the corresponding replacement alternate item are left blank,
- the proposal form submitted had the incorrect number of items, or
- all addenda were not acknowledged.

10. NONRESPONSIVE BID

The Owner will not accept a nonresponsive bid. A bid that has one or more of the deficiencies listed below is considered nonresponsive:

- The bid was not in the hands of the Letting Official at the time and location specified in the advertisement.
- A bid was submitted for the same project by a Bidder or Bidders and one or more of its partners or affiliates.
- The Bidder was not authorized to receive a proposal form under Article 2L.3, "Issuing Bid Documents",
- The Bidder failed to acknowledge receipt of all addenda issued.
- The proposal form was signed by a person who was not authorized to bind the Bidder or Bidders.
- The proposal guaranty did not comply with the requirements contained in this Item.
- The bid was in a form other than the official proposal form issued by the Owner.
- The Bidder modified the bid in a manner that altered the conditions or requirements for work as stated in the bid documents.
- The Bidder bid more than the maximum or less than the minimum number of allowable working days when working days was an item.
- The Bidder did not attend a specified mandatory pre-bid conference.
- The Bidder did not meet the requirements of the technical qualification.
- The Bidder did not include a signed State of Texas Child Support Business Ownership Form.
- The bidder is not prequalified by TxDOT

- The bidder does not meet the Owner's qualification requirements.

11. SUBMITTAL OF BIDS

Electronic Bids. Electronic bidding is not available.

Printed Bid.

- 2.1.1. **Proposal Form.** Mark all entries in ink. As an alternative to hand writing the unit prices in the proposal form, submit a typed proposal form. A typed proposal form must contain the information in the format shown on the "Example of Bid Prices Submitted by Computer Printout" in the proposal form.

When regular bid items have corresponding replacement alternate items, select the bid item or group of items to be used for the bid tabulation. Acknowledge all addenda by checking the appropriate box on the addendum acknowledgement page. Provide the complete and correct name of the Bidder submitting the bid. A person authorized to bind the Bidder must sign the proposal form. In the case of a joint venture, provide the complete and correct name of all Bidders submitting the bid. In the case of a joint venture, the person signing the proposal form must be authorized to bind all joint venture participants.

If a proposal form contains both regular items for domestic steel or iron materials and replacement alternate items for foreign steel or iron materials, the Bidder must either:

- submit unit bid prices for domestic items only, or
- submit unit bid prices for both the domestic and foreign items.

- 2.1.2. **Proposal Guaranty.** Provide a bid guaranty in the amount indicated on the bid documents. Use either a guaranty check or a printed bid bond. An electronic bid bond may be used as the guaranty. Ensure the electronic bid bond meets the requirements of Section 2L.8.1.2., "Proposal Guaranty," and submit the electronic bid bond with the printed bid.

- 2.1.3. **Guaranty Check.** Make the check payable to the Owner. The check must be a cashier's check, money order, or teller's check drawn by or on a state or national bank, or a state or federally chartered credit union (collectively referred to as "bank"). The check must be dated on or before the date of the bid opening. Postdated checks will not be accepted. The type of check or money order must be indicated on the face of the instrument, except in the case of a teller's check, and the instrument must be no more than 90 days old. A check must be made payable at or through the institution issuing the instrument; be drawn by a bank and on a bank; or be payable at or through a bank. The Owner will not accept personal checks, certified checks, or other types of money orders.

- 2.1.4. **Bid Bond.** Use the bid bond form provided by the Owner. Submit the bid bond with the powers of attorney attached and in the amount specified. The bond must be dated on or before the date of the bid opening, bear the impressed seal of the Surety, and be signed by the Bidder or Bidders and an authorized individual of the Surety. As an alternative for joint venture Bidders, each of the Bidders may submit a separate bid bond completed as outlined in this section. Bid bonds will only be accepted from Sureties authorized to execute a bond under and in accordance with State law.

- 2.1.5. **Submittal of Bid.** Place the completed proposal form and the bid guaranty in a sealed envelope marked to indicate the contents.

When submitting by mail or delivery service, place the envelope in another sealed envelope and address as indicated in the official advertisement or in the bid documents. It is the Bidder's responsibility to ensure that the sealed bid arrives at the location described on or before the time and date set for the bid opening. To be accepted, the bid must be in the hands of the Letting Official by that time of opening regardless of the method chosen for delivery.

- 2.1.6. **Revising the Proposal Form.** Make desired changes to the proposal form in ink and submit the bid to the Letting Official. The Owner will not make revisions to a bid on behalf of a Bidder.
- 2.1.7. **Withdrawing a Bid.** Submit a written request to withdraw a bid before the time and date set for the opening. The Owner will not accept oral requests. A written request must be signed and submitted to the Letting Official with proof of identification. The request must be made by a person authorized to bind the Bidder or Bidders. In the case of joint venture, the Owner will accept a request from any person authorized to bind a party to the joint venture. The Owner may require written delegation of authority to withdraw a bid when the individual sent to withdraw the bid is not authorized to bind the Bidder or Bidders.

12. OPENING AND READING OF BIDS

At the time, date, and location specified in the official advertisement, the Owner will publicly open and read bids.

13. TABULATING BIDS

Official Total Bid Amount. The Owner will sum the products of the quantities and the unit prices bid in the proposal form to determine the official total bid amount, except as provided in Section 2L.11., "Consideration of Unit Prices." The official total bid amount is the basis for determining the apparent low Bidder. The total bid amounts will be compared, and the results made public.

Consideration of Bid Format. When a Bidder submits both an electronic bid and a printed bid that is responsive, the unit bid prices in the printed bid will be used to determine the total bid amount. If the printed bid is incomplete or nonresponsive, the electronic bid will be used in the tabulation of the total bid amount.

If a Bidder submits 2 or more printed bids, all responsive bids will be tabulated. The bid with the lowest tabulation will be used to determine the total bid amount.

Rounding of Unit Prices. The Owner will round off all unit bids involving fractional parts of a cent to the nearest one-tenth cent (\$0.001) in determining the amount of the bid as well as computing the amount due for payment of each item under the Contract. For rounding purposes, entries of five-hundredths of a cent (\$0.0005) or more will be rounded up to the next highest tenth of a cent, while entries less than five-hundredths of a cent will be rounded down to the next lowest tenth of a cent.

Interpretation of Unit Prices. The Owner will make a documented determination of the unit bid price if a unit bid price is illegible or conflicting in the case of replacement alternate items. The Owner's determination will be final.

Consideration of Unit Prices.

- 2.1.1. **Additive Alternate Items.** The Owner will sum the products of the quantities and the unit prices for the regular items in the proposal form to determine the total bid amount for the base bid. The official total bid amount will be determined by the summation of the base bid plus a pre-determined order of additive alternate items. An estimate of the budgeted amount may be shown on the plans.

The Contract will identify the base bid work and additive alternate work to be performed. The Owner makes no guarantee that the additive alternate work will be required.

- 2.1.2. **A + B Bidding.** The official total bid amount will be determined by the summation of the Contract amount and the time element. The Owner will use the following formula to make the calculation:

$$A + B1 + B2 + BX + \dots + BT$$

The Contract amount, equal to A in the formula, is determined by the summation of the products of the approximate quantities shown in the bid and the unit bid prices bid. The time element, equal to B1, B2, BX

(when phases are included as bid components), and BT (substantial completion of the project when included as a bid component), of the bid is determined by multiplying the number of working days bid to substantially complete the project, or phases, by the daily road-user cost (RUC) provided on the bid documents. When partial days are bid they will be rounded up to the nearest whole day.

The formula above determines the low Bidder and establishes the Contract time.

- 2.1.3. **“Buy America.”** Comply with Buy America in accordance with Section 6L.1.1. For a Bidder who proposes to use foreign steel or iron materials to be considered the apparent low Bidder, their total bid must be at least 25% lower than the next lowest bid if that bid proposes to use domestic steel or iron materials.

This requirement does not apply to minimal use of steel or iron materials provided that the total cost of all foreign source items used in the project, as delivered to the project site, is less than \$2,500 or one-tenth-of-one-percent (1/10 of 1%) of the Contract amount, whichever is greater

14. **CONSIDERATION OF BID ERRORS.**

The Owner will consider a claim of a bid error by the apparent low Bidder if the following requirements have been met:

- Submit written notification to the Owner within 5 business days after the date the bid is opened.
- Identify the items of work involved and include bidding documentation. The Owner may request clarification of submitted documentation.

The Owner will evaluate the claim of an error by the apparent low Bidder by considering the following:

- The bid error relates to a material item of work.
- The bid error amount is a significant portion of the total bid.
- The bid error occurred despite the exercise of ordinary care.
- The delay of the proposed work will not impact cost and safety to the public.

Acceptance of the bid error claim by the Owner will result in the rejection of the bid of the apparent low bidder and the Owner may consider the second responsive bid. The erring Contractor will not be allowed to bid the project if it is relet. Rejection of bids due to the Contractor's bid error may result in the application of sanctions by the Owner.

15. **TIE BIDS**

If the official total bid amount for 2 or more Bidders is equal and those bids are the lowest submitted, each tie Bidder will be given an opportunity to withdraw their bid. If 2 or more tie Bidders do not withdraw their bids, the low Bidder will be determined by a coin toss. If all tie Bidders request to withdraw their bids, no withdrawals will be allowed, and the low Bidder will be determined by a coin toss. The Letting Official will preside over the proceedings for the coin toss.

Item 3L

Award and Execution of Contract



1. AWARD OF CONTRACT

The Owner will award, reject, or defer the Contract within 60 days after the opening of the bid. The Owner reserves the right to reject any or all bids and to waive minor technicalities in the best interest of the Owner.

Award. The Owner will award the Contract to the low Bidder as determined by Article 2L.10., "Tabulating Bids." The Owner may award a Contract to the second lowest Bidder when the following requirements have been met:

- The low Bidder withdraws its bid.
- The low Bidder fails to enter into a contract with the Owner after Award.
- The second low Bidder's unit bid prices are reasonable.

Rejection. The Owner will reject the Contract if:

- Collusion may have existed among the Bidders. Collusion participants will not be allowed to bid future bids for the same Contract.
- The low bid is mathematically and materially unbalanced. The Bidder will not be allowed to bid future bids for the same Contract.
- The lowest bid is higher than the Owner's estimate and re-advertising for bids may result in a lower bid.
- The low bid contains a bid error that satisfies the requirements and criteria in Article 2L.11 "Consideration of Bid Errors."
- Rejection of the Contract is in the best interest of the Owner.

Deferral. The Owner may defer the award or rejection of the Contract when deferral is in the best interest of the Owner.

2. RESCINDING OF AWARD

The Owner reserves the right to cancel the award of any Contract before Contract execution with no compensation due when the cancellation is in the best interest of the Owner. The Owner will return the proposal guaranty to the Contractor.

3. DISADVANTAGED BUSINESS ENTERPRISE (DBE)/HISTORICALLY UNDERUTILIZED BUSINESS/SMALL BUSINESS ENTERPRISE (SBE)

Submit all DBE/HUB/SBE information in the time frame specified when required by the bid documents.

4. EXECUTION OF CONTRACT

Provide the following within 15 days after written notification of award of the Contract:

Contract. Executed by Contractor and Surety.

Bonds. Executed performance bond and payment bond in the full amount of the Contract price with powers of attorney. Provide bonds in accordance with Table 1. Furnish the payment and performance bonds as a guaranty for the protection of the claimants and the Owner for labor and materials and the faithful performance of the work.

Table 1
Bonding Requirements

Contract Amount	Required Bonds
Less than \$25,000	None
\$25,000 to \$100,000	Payment
More than \$100,000	Performance and Payment

Insurance. Submit a Certificate of Insurance showing coverages in accordance with Contract requirements.

Insurances must cover the contracted work for the duration of the Contract and must remain in effect until final acceptance. Failure to obtain and maintain insurance for the contracted work may result in suspension of work or default of the Contract. If the insurance expires and coverage lapses for any reason, stop all work until the Owner receives an acceptable Certificate of Insurance.

Provide the Owner with a Certificate of Insurance verifying the types and amounts of coverage shown in Table 2. Provide as additional insured the Camino Real Regional Mobility Authority and County of El Paso. The Certificate of Insurance must be in a form approved by the Owner. Any Certificate of Insurance provided must be available for public inspection.

Table 2
Insurance Requirements

Type of Insurance	Amount of Coverage
Commercial General Liability Insurance	Not Less Than: \$600,000 each occurrence
Business Automobile Policy	Not Less Than: \$600,000 combined single limit
Workers' Compensation	Not Less Than: Statutory
All Risk Builder's Risk Insurance (For building-facilities Contracts only)	100% of Contract Price

By signing the Contract, the Contractor certifies compliance with all applicable laws, rules, and regulations pertaining to workers' compensation insurance. This certification includes all subcontractors. Pay all deductibles stated in the policy. Subcontractors must meet the requirements of Table 2 either through their own coverage or through the Contractor's coverage.

The Workers' Compensation policy must include a waiver of subrogation endorsement in favor of the Owner.

For building-facilities Contracts, provide All Risk Builder's Risk Insurance to protect the Owner against loss by storm, fire or extended coverage perils on work and materials intended for use on the project including the adjacent structure. Name the Owner under the Lost Payable Clause.

For Contracts with railroad requirements, see project-specific details for additional insurance requirements.

Provide a substitute Surety on the Contract bonds in the original full Contract amount within 15 days of notification if the Surety is declared bankrupt or insolvent, the Surety's underwriting limitation drops below the Contract amount or the Surety's right to do business is terminated by the Owner. The substitute Surety must be authorized by the laws of the State and acceptable to the Owner. Work will be suspended until a substitute Surety is provided. Working day charges will be suspended for 15 days or until an acceptable Surety is provided, whichever is sooner.

The work performed under this section will not be measured or paid for directly but will be subsidiary to pertinent items.

Business Ownership Information. Submit the names and social security numbers of all individuals owning 25% or more of the firm on the Owner's form.

Railroad Documents. Provide all required documents for satisfaction of railroad requirements for projects that have work which involves railroad right of way. Comply with the requirements of Article 5L.8., "Cooperation With Railroads."

5. FAILURE TO ENTER CONTRACT

If the Contractor fails to comply with all of the requirements in Article 3L.4., "Execution of Contract," the proposal guaranty will become the property of the Owner, not as a penalty, but as liquidated damages. The Contractor forfeiting the proposal guaranty will not be considered in future bids for the same work unless there has been a substantial change in design of the work.

6. APPROVAL AND EXECUTION OF CONTRACT

The Contract will be approved and signed under authority of the Owner.

7. RETURN OF PROPOSAL GUARANTY

The proposal guaranty check of the low Bidder will be retained until after the Contract has been rejected or awarded and executed. Bid bonds will not be returned.

8. BEGINNING OF WORK

Do not begin work until authorized in writing by the Owner.

Verify all quantities of materials shown on the plans before ordering.

For Contracts with callout work and work orders, the purchase of materials before a work order is issued or without prior written approval of the Engineer is at the Contractor's risk, and the Department is not obligated for the cost of the materials or work to acquire the materials.

9. ASSIGNMENT OF CONTRACT

Do not assign, sell, transfer, or otherwise dispose of the Contract or any portion rights, title, or interest (including claims) without the approval of the Owner or designated representative. The Owner must deem any proposed assignment justified and legally acceptable before the assignment can take place.

10. EXCLUDED PARTIES

The Contractor certifies by signing the Contract that the Contractor will not enter into any subcontract with a subcontractor that is debarred or suspended by the Owner or by any state or federal agency.

Item 4L

Scope of Work



11. CONTRACT INTENT

The intent of the Contract is to describe the completed work to be performed. Furnish materials, supplies, tools, equipment, labor, and other incidentals necessary for the proper prosecution and completion of the work in accordance with Contract documents.

12. PRECONSTRUCTION CONFERENCE

Before starting work, schedule and attend a preconstruction conference with the Owner. Failure to schedule and attend a preconstruction conference is not grounds for delaying the beginning of working day charges. The preconstruction conference may be scheduled with the safety preconstruction meeting described in Section 7L.1.2., "Safety Preconstruction Meeting."

Issue Resolution Process. An issue is any aspect of the Contract where parties of the Contract do not agree. The individuals identified at the lowest level of the issue escalation ladder will initiate the issue resolution process by escalating any issue that remains unresolved within the time frame outlined in the issue escalation ladder.

Work with the Owner to resolve all issues during the course of the Contract. Refer to Article 4L.7., "Dispute or Claims Procedure," for all unresolved issues.

13. PARTNERING

The intent of this Article is to promote an environment of trust, mutual respect, integrity, and fair-dealing between the Owner and the Contractor.

Informal partnering does not make use of a facilitator, while formal partnering uses the services of a facilitator (internal or external).

Procedures for Partnering Meetings and Format. Informal partnering is required, unless formal partnering is mutually agreed to instead of the informal partnering.

Facilitators. The facilitator is to act as a neutral party seeking to initiate cooperative working relationships. This individual must have the technical knowledge and ability to lead and guide discussions. Choose either an internal or external facilitator. The facilitator must be acceptable to the Engineer.

2.1.1. **Internal Facilitators.** An Owner or Contractor internal (staff) facilitator may be selected as the facilitator at no additional cost to either party.

2.1.2. **External Facilitators.** A private firm or individual that is independent of the Contractor and the Owner may be selected as the facilitator. Submit the facilitator's name and estimated fees for approval before contracting with the facilitator.

Meetings and Arrangements. Coordinate with the Engineer for meeting dates and times, locations including third party facilities, and other needs and appurtenances, including, but not limited to, audio or visual equipment. Make all meeting arrangements for formal partnering. Use Owner facilities or facilities in the vicinity of the project if available. Submit the estimated meeting costs for approval before finalizing arrangements.

Coordinate facilitator discussions before the partnering meeting to allow the facilitator time to prepare an appropriate agenda. Prepare a list of attendees with job titles and include critical Contractor, subcontractor, and supplier staff in the list. Provide the facilitator the list of attendees and invite the attendees listed.

The Owner will invite and provide a list of attendees that includes, but is not limited to, Owner, TxDOT, other local governments, law enforcement, railroad, and utility representatives.

Participate in additional partnering meetings as mutually agreed.

Payment. Expenses for labor, Contractor equipment, or overhead will not be allowed. Markups as prescribed in Article 9L.7., "Payment for Extra Work and Force Account Method," will not be allowed.

Informal partnering will be conducted with each party responsible for their own costs.

For formal partnering using internal facilitators, the Contractor will be responsible for arrangements and for expenses incurred by its internal facilitator, including, but not limited to, meals, travel, and lodging. Owner facilitators, if available, may be used at no additional cost.

For formal partnering using external facilitators, submit an invoice to the Engineer for reimbursement. The Owner will reimburse the Contractor for half of the eligible expenses as approved. For external facilitators not approved by the Owner but used at the Contractor's option, the Contractor will be responsible for all costs of the external facilitator.

For meeting facilities and appurtenances, submit an invoice to the Engineer for reimbursement. The Owner will reimburse the Contractor for half of the eligible expenses as approved.

14. CHANGES IN THE WORK

The Engineer reserves the right to make changes in the work including addition, reduction, or elimination of quantities and alterations needed to complete the Contract. Perform the work as altered. These changes will not invalidate the Contract nor release the Surety. The Contractor is responsible for notifying the sureties of any changes to the Contract.

If the changes in quantities or the alterations do not significantly change the character of the work under the Contract, the altered work will be paid for at the Contract unit price. If the changes in quantities or the alterations significantly change the character of the work, the Contract will be amended by a change order. If no unit prices exist, this will be considered extra work and the Contract will be amended by a change order. Provide cost justification as requested, in an acceptable format. Payment will not be made for anticipated profits on work that is eliminated.

Agree on the scope of work and the basis of payment for the change order before beginning the work. If there is no agreement, the Engineer may order the work to proceed under Article 9L.7., "Payment for Extra Work and Force Account Method," or by making an interim adjustment to the Contract. In the case of an adjustment, the Engineer will consider modifying the compensation after the work is performed.

A significant change in the character of the work occurs when:

- the character of the work for any item as altered differs materially in kind or nature from that in the Contract or
- a major item of work varies by more or less than 25% from the original Contract quantity.

When the quantity of work to be done under any major item of the Contract is more than 125% of the original quantity stated in the Contract, then either party to the Contract may request an adjustment to the unit price on the portion of the work that is above 125%.

When the quantity of work to be done under any major item of the Contract is less than 75% of the original quantity stated in the Contract, then either party to the Contract may request an adjustment to the unit price. When mutually agreed, the unit price may be adjusted by multiplying the Contract unit price by the factor in Table 1. If an adjusted unit price cannot be agreed upon, the Engineer may determine the unit price by multiplying the Contract unit price by the factor in Table 1.

Table 1
Quantity-Based Price Adjustment Factors

% of Original Quantity	Factor
≥ 50 and < 75	1.05
≥ 25 and < 50	1.15
< 25	1.25

If the changes require additional working days to complete the Contract, Contract working days will be adjusted in accordance with Item 8L, "Prosecution and Progress."

15. DIFFERING SITE CONDITIONS

During the progress of the work, differing subsurface or latent physical conditions may be encountered at the site. The 2 types of differing site conditions are defined as:

- those that differ materially from those indicated in the Contract and
- unknown physical conditions of an unusual nature differing materially from those ordinarily encountered and generally recognized as inherent in the work provided for in the Contract.

Notify the Engineer in writing when differing site conditions are encountered. The Engineer will notify the Contractor when the Owner discovers differing site conditions. Unless directed otherwise, do not work on the affected items and leave the site undisturbed. The Engineer will investigate the conditions and determine whether differing site conditions exist. If the differing site conditions cause an increase or decrease in the cost or number of working days specified for the performance of the Contract, the Engineer will make adjustments, excluding the loss of anticipated profits, in accordance with the Contract. Additional compensation will be made only if the required written notice has been provided.

16. REQUESTS FOR ADDITIONAL COMPENSATION

Notify the Engineer in writing of any intent to request additional compensation once there is knowledge of the basis for the request. An assessment of damages is not required to be part of this notice but is desirable. The intent of the written notice requirement is to provide the Owner an opportunity to evaluate the request and to keep an accurate account of the actual costs that may arise. Minimize impacts and costs.

If written notice is not given, the Contractor waives the right to additional compensation unless the circumstances could have reasonably prevented the Contractor from knowing the cost impact before performing the work. Notice of the request and the documentation of the costs will not be construed as proof or substantiation of the validity of the request. Submit the request in enough detail to enable the Owner to determine the basis for entitlement, adjustment in the number of working days specified in the Contract, and compensation.

The Owner will not consider fees and interest on requests for additional compensation. Fees include, but are not limited to: preparation, attorney, printing, shipping, and various other fees.

Damages occur when impacts that are the responsibility of the Owner result in additional costs to the Contractor that could not have been reasonably anticipated at the time of letting. Costs of performing additional work are not considered damages. For Contractor damages, the intent is to reimburse the Contractor for actual expenses arising out of a compensable impact. No profit or markups, other than labor burden, will be allowed. For damages, labor burden will be reimbursed at 35% unless the Contractor can justify higher actual cost. Justification for a higher percentage must be in accordance with the methodology provided by the Owner, submitted separately for project overhead labor and direct labor, and determined and

submitted by a Certified Public Accountant (CPA). Submit CPA-prepared labor burden rates directly to the Owner.

If the Contractor requests compensation for delay damages and the delay is determined to be compensable, then standby equipment costs and project overhead compensation will be based on the duration of the compensable delay and will be limited as follows:

Standby Equipment Costs. Payment will be made in accordance with Section 9L.7.1.4.3., "Standby Equipment Costs."

Project Overhead. Project overhead is defined as the administrative and supervisory expenses incurred at the work locations. When delay to project completion occurs, reimbursement for project overhead for the Contractor will be made using the following options:

- reimbursed at 6% (computed as daily cost by dividing 6% of the original Contract amount by the number of original Contract work days), or
- actual documented costs for the impacted period.

Project overhead for delays impacting subcontractors will be determined from actual documented costs submitted by the Contractor.

Time extensions and suspensions alone will not be justification for reimbursement for project overhead.

Home Office Overhead. The Owner will not compensate the Contractor for home office overhead.

17. DISPUTE OR CLAIMS PROCEDURE

The dispute resolution policy promotes a cooperative attitude between the Engineer and Contractor. Emphasis is placed on resolving issues while they are still current, at the project office, and in an informal manner. Open sharing of information is encouraged by all parties involved so the information provided completely and accurately reflects the issues and facts. If information is not shared, decisions may be limited to relying on the documentation that is available for review.

The Owner's goal is to have a dispute settled by the Engineer before elevating it as a claim.

If a dispute cannot be resolved, initiate the Contract claim procedure by filing a Contract claim after the completion of the Contract or when required for orderly performance of the Contract. Submit the claim to the Owner in accordance with state law.

For a claim resulting from enforcement of a warranty period, file the claim no later than one year after expiration of the warranty period. For all other claims, file the claim no later than the date the Owner issues notice to the Contractor that they are in default, the date the Owner terminates the Contract, or one year after the date of final acceptance of the Contract. It is the Contractor's responsibility to submit requests in a timely manner.

Item 5L

Control of the Work



1. AUTHORITY OF ENGINEER

The Engineer has the authority to observe, test, inspect, approve, and accept the work on behalf of the Owner. The Engineer decides all questions about the quality and acceptability of materials, work performed, work progress, Contract interpretations, and acceptable Contract fulfillment. The Engineer has the authority to enforce and make effective these decisions.

The Engineer acts as a referee in all questions arising under the terms of the Contract. The Engineer's decisions will be final and binding.

The Engineer may pursue actions against the Contractor, including but not limited to the withholding of payments and suspending the work, for noncompliance of the Contract.

The Engineer may suspend the work without suspending working day charges for noncompliance of the Contract.

2. PLANS AND WORKING DRAWINGS

When required, provide working drawings to supplement the plans with all necessary details not included on the Contract plans. Prepare and furnish working drawings in a timely manner and obtain approval, if required, before the beginning of the associated work. For all working drawing submittal requirements, the Engineer may allow electronic and other alternative submission procedures. Have a licensed professional engineer sign, seal, and date the working drawings as indicated in Table 1.

Prepare working drawings using United States standard measures in the English language. The routing of submittals for review and approval will be established at the preconstruction conference. The Contractor is responsible for the accuracy, coordination, and conformity of the various components and details of the working drawings. Owner approval of the Contractor's working drawings will not relieve the Contractor of any responsibility under the Contract. The work performed under this article will not be measured or paid for directly but will be subsidiary to pertinent items.

Table 1
Signature and Approval Requirements for Working Drawings

Working Drawings For		Requires Licensed Professional Engineer's Signature, Seal, and Date	Requires Owner Approval
1. Alternate or optional designs submitted by Contractor		Yes	Yes
2. Supplementary shop and fabrication drawings for structural Items		No unless required on the plans	See applicable Item
3. Contractor-proposed temporary facilities that affect the public safety, not included on the plans		Yes	Yes
4. Form and falsework details	Bridges, retaining walls, and other major structures	Yes unless otherwise shown on the plans	No ¹
	Minor structures	No unless otherwise shown on the plans	No
5. Erection drawings		Yes	No ^{1,2}
6. Contractor-proposed major modifications to traffic control plan		Yes	Yes

1. The Engineer may require that the Contractor have a licensed professional engineer certify that the temporary works are constructed according to the sealed drawings.
2. Approval is required for items spanning over live traffic or where safety of the traveling public is affected, in the opinion of the Engineer.

Submit shop drawings electronically for the fabrication of structural items.

3. CONFORMITY WITH PLANS, SPECIFICATIONS, AND SPECIAL PROVISIONS

Furnish materials and perform work in reasonably close conformity with the lines, grades, cross-sections, dimensions, details, gradations, physical and chemical characteristics of materials, and other requirements shown in the Contract (including additional plans for non-site-specific work). Reasonably close conformity limits will be as defined in the respective items of the Contract or, if not defined, as determined by the Engineer. Obtain approval before deviating from the plans and approved working drawings. Do not perform work beyond the lines and grades shown on the plans or any extra work without the Engineer's approval. Work performed beyond the lines and grades shown on the plans or any extra work performed without approval is considered unauthorized and excluded from pay consideration. The Owner will not pay for material rejected due to improper fabrication, excess quantity, or any other reasons within the Contractor's control.

Acceptance of Defective or Unauthorized Work. When work fails to meet Contract requirements, but is adequate to serve the design purpose, the Engineer will decide the extent to which the work will be accepted and remain in place. The Engineer will document the basis of acceptance by a letter and may adjust the Contract price.

Correction of Defective or Unauthorized Work. When work fails to meet Contract requirements and is inadequate to serve the design purpose it will be considered defective. Correct, or remove and replace, the work at the Contractor's expense, as directed.

The Engineer has the authority to correct or to remove and replace defective or unauthorized work. The cost may be deducted from any money due or to become due to the Contractor.

4. COORDINATION OF PLANS, SPECIFICATIONS, AND SPECIAL PROVISIONS

The specifications, accompanying plans (including additional plans for non-site-specific work), special provisions, change orders, and supplemental agreements are intended to work together and be interpreted as a whole.

Numerical dimensions govern over scaled dimensions. Special provisions govern over plans (including general notes), which govern over standard specifications and special specifications. Job-specific plan sheets govern over standard plan sheets.

However, in the case of conflict between plans (including general notes) and specifications regarding responsibilities for hazardous materials and traffic control in Items 1L through 9L and Item 502, "Barricades, Signs, and Traffic Handling," special provisions govern over standard specifications and special specifications, which govern over the plans.

Notify the Engineer promptly of any omissions, errors, or discrepancies discovered so that necessary corrections and interpretations can be made. Failure to promptly notify the Engineer will constitute a waiver of all claims for misunderstandings or ambiguities that result from the errors, omissions, or discrepancies discovered.

5. COOPERATION OF CONTRACTOR

Cooperate with the Engineer. Respond promptly to instructions from the Engineer. Provide all information necessary to administer the Contract.

Designate in writing a competent, English-speaking Superintendent employed by the Contractor. The Superintendent must be experienced with the work being performed and capable of reading and understanding the Contract. Ensure the Superintendent is available at all times and able to receive instructions from the Engineer or authorized Owner representatives and to act for the Contractor. The Engineer may suspend work without suspending working day charges if a Superintendent is not available or does not meet the above criteria.

At the written request of the Engineer, immediately remove from the project any employee or representative of the Contractor or a subcontractor who, in the opinion of the Engineer, does not perform work in a proper and skillful manner or who is disrespectful, intemperate, disorderly, uncooperative, or otherwise objectionable. Do not reinstate these individuals without the written consent of the Engineer.

Furnish suitable machinery, equipment, and construction forces for the proper prosecution of the work. Provide adequate lighting to address quality requirements and inspection of nighttime work.

The Engineer may suspend the work without suspending working day charges until the Contractor complies with this requirement. All work associated with fulfilling this requirement is subsidiary to the various items of the Contract and no direct compensation will be made.

6. COOPERATING WITH UTILITIES

Use established safety practices when working near utilities. Consult with the appropriate utilities before beginning work. Notify the Engineer immediately of utility conflicts. The Engineer will decide whether to adjust utilities or adjust the work to eliminate or lessen the conflict. Unless otherwise shown on the plans, the Engineer will make necessary arrangements with the utility owner when utility adjustments are required.

Use work procedures that protect utilities or appurtenances that remain in place during construction. Cooperate with utilities to remove and rearrange utilities to avoid service interruption or duplicate work by the utilities. Allow utilities access to the right of way.

Immediately notify the appropriate utility of service interruptions resulting from damage due to construction activities. Cooperate with utilities until service is restored. Maintain access to active fire hydrants at all times unless approved by the Engineer.

7. COOPERATION BETWEEN CONTRACTORS

Cooperate and coordinate with other Contractors working within the limits or adjacent to the limits.

8. COOPERATION WITH RAILROADS

Plan and prosecute portions of the work involving a railway to avoid interference with or hindrance to the railroad company.

If the work is on railroad right of way, do not interfere with the operation of the railroad company's trains or other property.

Project-Specific Information. Refer to project-specific plan sheets in the Contract for specific information concerning the work to be completed by both the Contractor and the railroad within railroad right of way; railroad right of way locations impacted by construction; percentage of Contract work at each location; train movements at each location; and requirements for railroad insurance, flagging, and Right of Entry (ROE) Agreements.

Right of Entry Agreement (if required). The process for obtaining a fully executed ROE Agreement will be as follows:

- The Owner will send the unexecuted ROE Agreement to the Contractor with the unexecuted construction Contract.
- Partially execute the ROE Agreement and return it to the Department with the required insurance attached.
- The Owner will coordinate with the railroad company regarding the further execution of the ROE Agreement and associated fees. The Owner will pay any ROE Agreement fees directly to the railroad company.
- Once the Owner has received the fully-executed ROE Agreement from the railroad company, the Owner will forward the fully-executed ROE Agreement to the Contractor.

9. CONSTRUCTION SURVEYING

Use Method C unless otherwise specified in the Contract. Upon request, the Engineer will allow the Contractor to copy available earthwork cross-sections, computer printouts or data files, and other information necessary to establish and control work. Maintain the integrity of control points. Preserve all control points, stakes, marks, and right of way markers. Assume cost and responsibility of replacing disturbed control points, stakes, marks, and right of way markers damaged by the Contractor's or its subcontractor operations. If the Owner repairs disturbed control points, stakes, marks, or right of way markers, the cost of repair may be deducted from money due or to become due to the Contractor. Replace right of way markers under the direction of a RPLS. This work will be subsidiary to pertinent items.

The Engineer reserves the right to make measurements and surveys to determine the accuracy of the work and determine pay quantities. The Engineer's measurements and surveys do not relieve the Contractor's responsibility for accuracy of work. Allow the Engineer adequate time to verify the surveying.

Method A. The Engineer will set control points for establishing lines, slopes, grades, and centerlines and for providing both vertical and horizontal control. At a minimum, provide a controlling pair of monument points at both the beginning and end of construction project for projects less than 2 miles in length. For projects greater than 2 miles in length, monuments will be set in pairs of 2 at a minimum of 2 miles based on the overall length of the project. Use these control points as reference to perform the work.

Furnish materials, equipment, and qualified workforce necessary for the construction survey work. Place construction points, stakes, and marks at intervals sufficient to control work to established tolerances. Place construction stakes at intervals of no more than 100 ft., or as directed. Place stakes and marks so as not to interfere with normal maintenance operations.

Method B. The Engineer will set adequate control points, stakes, and marks to establish lines, slopes, grades, and centerlines. Furnish additional work, stakes, materials, and templates necessary for marking and maintaining points and lines.

Method C. Set adequate control points, stakes, and marks to establish lines, slopes, grades, and centerlines.

10. INSPECTION

Inspectors are authorized representatives of the Engineer. Inspectors are authorized to examine all work performed and materials furnished, including preparation, fabrication, and material manufacture. Inspectors inform the Contractor of failures to meet Contract requirements. Inspectors may reject work or materials and may suspend work until any issues can be referred to and decided by the Engineer. Inspectors cannot alter, add, or waive Contract provisions, issue instructions contrary to the Contract, act as foremen for the Contractor, or interfere with the management of the work. Inspection, or lack of inspection, will not relieve the Contractor from obligation to provide materials or perform the work in accordance with the Contract.

Provide safe access to all parts of the work and provide information and assistance to the Engineer to allow a complete and detailed inspection. Give the Engineer sufficient notice to inspect the work. Work performed without suitable inspection, as determined by the Engineer, may be ordered removed and replaced at Contractor's expense. Remove or uncover portions of finished work as directed. Once inspected, restore work to Contract requirements. If the uncovered work is acceptable, the costs to uncover, remove, and replace or make good the parts removed will be paid for in accordance with Article 4L.4., "Changes in the Work." If the work is unacceptable, assume all costs associated with repair or replacement, including the costs to uncover, remove, and replace or make good the parts removed.

When a government entity, utility, railroad company, or other entity accepts or pays a portion of the Contract, that organization's representatives may inspect the work but cannot direct the Contractor. The right of inspection does not make that entity a party to the Contract and does not interfere with the rights of the parties to the Contract.

11. FINAL CLEANUP

Upon completion of the work, remove litter, debris, objectionable material, temporary structures, excess materials, and equipment from the work locations. Clean and restore property damaged by the Contractor's operations during the prosecution of the work. Leave the work locations in a neat and presentable condition.

Remove from the right of way cofferdams, construction buildings, material and fabrication plants, temporary structures, excess materials, and debris resulting from construction. Where work is in a stream, remove debris to the ground line of the bed of the stream. Leave stream channels and rights of way in a neat and presentable condition. Clean structures to the flow line or the elevation of the outfall channel, whichever is higher. Dispose of all excess material in accordance with federal, state, and local regulations.

The work performed under this Article will not be paid for directly but will be considered subsidiary to Items of the Contract.

12. FINAL ACCEPTANCE

Final acceptance is made when all work is complete and the Engineer, in writing, accepts all work for the work locations in the Contract. Final acceptance relieves the Contractor from further Contract responsibilities.

2.1.1. **Work Completed.** Work completed must include work for vegetative establishment and maintenance, test, and performance periods and work to meet the requirements of Article 5L.11., "Final Cleanup."

2.1.2. **Final Inspection.** After all work is complete, the Contractor will request a final inspection by the Engineer authorized to accept the work.

The final inspection will be made as soon as possible, and not later than 10 calendar days after the request. No working day charges will be made between the date of request and final inspection.

After the final inspection, if the work is satisfactory, the Engineer will notify the Contractor in writing of the final acceptance of the work. If the final inspection finds any work to be unsatisfactory, the Engineer will identify in writing all deficiencies in the work requiring correction. Correct the deficiencies identified. Working day charges will resume if these deficiencies are not corrected within 7 calendar days, unless otherwise authorized by the Engineer. Upon correction, the Engineer will make an inspection to verify that all deficiencies were corrected satisfactorily. The Engineer will provide written notice of the final acceptance.

2.1.3. **Final Measurement.** Final measurements and pay quantity adjustments may be made after final acceptance.

2.1.4. **Removal of Traffic Control Devices.** Remove construction traffic control devices and advance warning signs upon final acceptance or as directed.

Item 6L

Control of Materials



1. SOURCE CONTROL

Use only materials that meet Contract requirements. Unless otherwise specified or approved, use new materials for the work. Secure the Engineer's approval of the proposed source of materials to be used before their delivery. Materials can be approved at a supply source or staging area but may be reinspected in accordance with Article 6L.4., "Sampling, Testing, and Inspection."

Buy America. Comply with the latest provisions of Buy America as listed at 23 CFR 635.410. Use steel or iron materials manufactured in the United States except when:

- the cost of materials, including delivery, does not exceed 0.1% of the total Contract cost or \$2,500, whichever is greater;
- the Contract contains a replacement alternate item for a foreign source steel or iron product and the Contract is awarded based on the replacement alternate item; or
- the materials are temporarily installed.

Provide a notarized original of the TxDOT FORM D-9-USA-1 (Department Form 1818 or equivalent) with the proper attachments for verification of compliance.

Manufacturing is any process that modifies the chemical content, physical shape or size, or final finish of a product. Manufacturing begins with initial melting and mixing and continues through fabrication (cutting, drilling, welding, bending, etc.) and coating (paint, galvanizing, epoxy, etc.).

1.2. **Convict Produced Materials.** Materials produced by convict labor may only be incorporated in the work if such materials have been:

- produced by convicts who are on parole, supervised release, or probation from prison; or
- produced in a qualified prison facility.

A "qualified prison facility" means any prison facility in which convicts, during the 12-month period ending July 1, 1987, produced materials for use in federal-aid highway construction projects.

2. MATERIAL QUALITY

Correct or remove materials that fail to meet Contract requirements or that do not produce satisfactory results. Reimburse the Owner for cost incurred if additional sampling and testing is required by a change of source.

Materials not meeting Contract requirements will be rejected, unless the Engineer approves corrective actions. Upon rejection, immediately remove and replace rejected materials.

If the Contractor does not comply with this article, the Owner may have defective material removed and replaced. The cost of testing, removal, and replacement will be deducted from the payments due to the Contractor.

3. MANUFACTURER WARRANTIES

Transfer to the Owner warranties and guarantees required by the Contract or received as part of normal trade practice.

4. SAMPLING, TESTING, AND INSPECTION

Incorporate into the work only material that has been inspected, tested, and accepted by the Engineer. Remove, at the Contractor's expense, materials from the work locations that are used without prior testing and approval or written permission.

Unless otherwise mutually agreed, the material requirements and standard test methods in effect at the time the proposed Contract is advertised govern. Unless otherwise noted, the Engineer will perform testing at Owner's expense. In addition to facilities and equipment required by the Contract, furnish facilities and calibrated equipment required for tests to control the manufacture of construction items. If requested, provide a complete written statement of the origin, composition, and manufacture of materials.

All materials used are subject to inspection or testing at any time during preparation or use. Material which has been tested and approved at a supply source or staging area may be reinspected or tested before or during incorporation into the work and rejected if it does not meet Contract requirements. Copies of test results are to be made available upon request. Do not use material that, after approval, becomes unfit for use.

Unless otherwise noted in the Contract, all testing must be performed within the United States and witnessed by the Engineer. If materials or processes require testing outside the contiguous 48 United States, reimburse the Owner for inspection expenses.

5. PLANT INSPECTION AND TESTING

The Engineer may, but is not obligated to, inspect materials at the acquisition or manufacturing source. Material samples will be obtained and tested for compliance with quality requirements.

If inspection is at the plant, meet the following conditions unless otherwise specified:

- Cooperate fully and assist the Engineer during the inspection.
- Ensure the Engineer has full access to all parts of the plant used to manufacture or produce materials.
- In accordance with pertinent items and the Contract, provide a facility at the plant for use by the Engineer as an office or laboratory.
- Provide and maintain adequate safety measures and restroom facilities.
- Furnish and calibrate scales, measuring devices, and other necessary equipment.

The Engineer may provide inspection for periods other than daylight hours if:

- continuous production of materials for Owner use is necessary due to the production volume being handled at the plant, and
- the lighting is adequate to allow satisfactory inspection.

6. STORAGE OF MATERIALS

Store and handle materials to preserve their quality and fitness for the work. Store materials so that they can be easily inspected and retested. Place materials under cover, on wooden platforms, or on other hard, clean surfaces as necessary or when directed.

Obtain approval to store materials on the right of way. Storage space off the right of way is at the Contractor's expense.

7. OWNER-FURNISHED MATERIAL

The Owner will supply materials as shown in the Contract documents. The cost of handling and placing materials supplied by the Owner will not be paid for directly but is subsidiary to the item in which they are used. Assume responsibility for materials upon receipt.

8. USE OF MATERIALS FOUND ON THE RIGHT OF WAY

Material found in the excavation areas and meeting the Owner's specifications may be used in the work. This material will be paid for at the Contract bid price for excavation and under the item for which the material is used.

Do not excavate or remove any material from within the right of way that is not within the limits of the excavation without written permission. If excavation is allowed within a right of way project-specific location (PSL), replace the removed material with suitable material at no cost to the Owner as directed.

9. RECYCLED MATERIALS

The Owner will not allow hazardous wastes, as defined in 30 TAC 335, proposed for recycling to be used on the project. Use nonhazardous recyclable materials (NRMs) only if the specification for the item does not disallow or restrict use. Determine if NRMs are regulated under 30 TAC 312, 330, 332, 334, or 335, and comply with all general prohibitions and requirements. Use NRMs in accordance with DMS-11000, "Evaluating and Using Nonhazardous Recyclable Materials Guidelines," and furnish all documentation required by that specification.

10. HAZARDOUS MATERIALS

Comply with the requirements of Article 7L.11., "Responsibility for Hazardous Materials."

Use materials that are free of hazardous materials as defined in Item 1L, "Abbreviations and Definitions."

Notify the Engineer immediately when a visual observation or odor indicates that materials in required material sources or on sites owned or controlled by the owner may contain hazardous materials. Except when the contract includes bid items for the contractor to remove hazardous materials, the Engineer is responsible for testing and removing or disposing of hazardous materials not introduced by the Contractor on sites owned or controlled by the Owner as indicated below.

The plans will indicate locations where paint on steel is suspected to contain hazardous materials and where regulated asbestos containing materials have been found. The Engineer may suspend work wholly or in part during the testing, removal, or disposition of hazardous materials on sites owned or controlled by the Owner, except in the case of when the contract includes removing and disposing of hazardous materials.

When a visual observation or odor indicates that materials delivered to the work locations by the Contractor may contain hazardous materials, have an approved commercial laboratory test the materials for contamination. Remove, remediate, and dispose of any of these materials found to be contaminated. Testing, removal, and disposition of hazardous materials introduced onto the work locations by the Contractor will be at the Contractor's expense. Working day charges will not be suspended and extensions of working days will not be granted for activities related to handling hazardous material delivered by the Contractor.

Painted Steel Requirements. Paint containing hazardous materials will be removed as shown on the plans.

- 2.1.1. **Paint Removed by Third Party.** The Owner may provide a third party to remove paint containing hazardous materials where paint must be removed to perform work or to allow dismantling of the steel.

2.1.2.

Paint Removed by the Contractor. This work may only be performed by a firm or company with one of the following certifications:

- SSPC-QP2 certification for lead painting operations, or
- Certified Lead Firm by the Texas Department of State Health Services.

Maintain certification for the duration of the work. Provide copies of audits or certification if requested.

Comply with worker and public safety regulations, including, but not limited to, OSHA 29 CFR Parts 1910.1025, 1926.62, and 1926.63. Monitor permissible exposure limits in accordance with OSHA requirements.

Remove paint containing hazardous materials from designated areas shown on the plans or as directed. Comply with access limitations shown on the plans.

Provide power hand tools, equipped with high-efficiency particulate air filter vacuums to mechanically remove paint.

Contain, collect, store, transport, and dispose of all waste generated by cleaning operation in accordance with local, state, and federal requirements including 40 CFR 302. Properly characterize and dispose of all wastes. Manage any hazardous wastes in accordance with regulatory requirements and dispose in a facility authorized to accept such wastes. Provide copies of disposal manifests.

The work performed, materials furnished, equipment, labor, tools, and incidentals will be paid for in accordance with Item 446, "Field Cleaning and Painting Steel."

Removal and Disposal of Painted Steel. Painted steel will be disposed of at a steel recycling or smelting facility unless otherwise shown on the plans. If the paint contains hazardous materials, maintain, and make available to the Engineer invoices and other records obtained from the facility showing the received weight of the steel and the facility name.

For steel that is dismantled by unbolting, no paint stripping will be required. Use care to not damage existing paint. When dismantling is performed using flame or saw-cutting methods to remove steel elements coated with paint containing hazardous materials, the plans will show stripping locations.

The work provided, materials furnished, equipment, labor, tools, and incidentals will be paid for in accordance with Item 496, "Removing Structures," and Item 497, "Sale of Salvagable Material."

Asbestos Requirements. The plans will indicate locations or elements where asbestos containing materials (ACM) have been found. For work at these locations, notify the Engineer of proposed dates of demolition or removal of structural elements with ACM at least 60 days before work is to begin to allow the Owner enough time to abate the asbestos.

The Department of State Health Services (DSHS), Asbestos Programs Branch, is responsible for administering the requirements of the National Emissions Standards for Hazardous Air Pollutants, 40 CFR Part 61, Subpart M (NESHAP) and the Texas Asbestos Health Protection Rules (TAHPR). Based on EPA guidance and regulatory background information, bridges are considered to be a regulated "facility" under NESHAP. Therefore, federal standards for demolition and renovation apply.

DSHS requires that notifications be postmarked at least 10 working days before initiating demolition or renovation of each structure or load bearing member shown on the plans. If the actual demolition, renovation, or removal date is changed or delayed, notify the Engineer in writing of these revised dates in sufficient time to allow for the Owner's notification to DSHS to be postmarked at least 10 days in advance of the work.

Failure to provide the above information may require the temporary suspension of work under Article 8L.4., "Temporary Suspension of Work or Working Day Charges," due to reasons under the control of the

Contractor. The Owner retains the right to determine the actual advance notice needed for the change in date to address post office business days and staff availability.

2.1.3. **Asbestos Removed by Third Party.** At locations where unknown ACM is discovered, the Owner will arrange for abatement by a third party.

2.1.4. **Asbestos Removed by the Contractor.** Maintain certification as Asbestos Abatement Contractor by the Texas Department of State Health Services for the duration of the Contract. Provide copies of audits and certification to the Engineer.

Work Performed by a Third Party. When the work for removal of paint or asbestos abatement is to be provided by a third party, coordinate and cooperate with the third party and the Owner. Continue other work detailed on the plans not directly involved in the paint removal or asbestos abatement work. Provide notice to the Owner regarding the progress of the work to allow the Owner enough time to schedule the third-party work.

11. **SURPLUS MATERIALS**

Take ownership of surplus materials unless otherwise shown on the plans or as directed by the Engineer. Remove and dispose of materials in accordance with federal, state, and local regulations. If requested, provide an appropriate level of documentation to verify proper disposal. When materials are disposed of on private property, provide written authorization from the property owner for the use of the property for this purpose upon request.

Item 7L

Legal Relations and Responsibilities



1. SAFETY

Point of Contact. Designate a Contractor Safety Point of Contact (CSPOC). The Owner will assign an Owner employee for their point of contact designated as Owner's Safety Point of Contact OSPOC. The CSPOC will ensure that the Contractor's and Subcontractor's employees' use the appropriate personal protection equipment (hard hats, safety vests, protective toe footwear, etc.).

The CSPOC will ensure that crew leaders and foremen (including subcontractors) have attended the required training.

Safety Preconstruction Meeting. In cooperation with the Engineer, schedule and attend a safety preconstruction meeting (may be a part of the preconstruction conference in Article 4L.2., "Preconstruction Conference." Attendees for this safety preconstruction meeting will be:

- the Contractor,
- subcontractor's,
- Owner,
- local law enforcement, and
- other personnel that play an active role on the project.

Public Safety and Convenience. Ensure the safety and convenience of the public and property as provided in the Contract and as directed by the Engineer. Keep existing roadways open to traffic or construct and maintain detours and temporary structures for safe public travel. Manage construction to minimize disruption to traffic. Maintain the roadway in a good and passable condition, including proper drainage and provide for ingress and egress to adjacent property.

Store all equipment not in use in a manner and at locations that will not interfere with the safe passage of traffic.

Provide qualified flaggers in accordance with Item 502.2.2., "Flaggers," for the safety and convenience of the traveling public and workers, as directed.

If the Engineer determines that any of the requirements of this article have not been met, the Engineer may take any necessary corrective action. This will not change the legal responsibilities set forth in the Contract. The cost to the Owner for this work will be deducted from any money due or to become due to the Contractor.

Use of Blue Warning Lights. Texas Transportation Code 547.105 authorizes the use of warning lights to promote safety and provides an effective means of gaining the travelling public's attention as they drive in areas where construction crews are present. In order to influence the public to move over when high risk construction activities are taking place, minimize the utilization of blue warning lights. These lights must be used only while performing work on or near the travel lanes or shoulder where the travelling public encounters construction crews that are not protected by a standard work zone set up such as a lane closure, shoulder closure, or one-way traffic control. Refrain from leaving the warning lights engaged while travelling from one work location to another or while parked on the right of way away from the pavement or a work zone.

Barricades, Warning and Detour Signs, and Traffic Handling. Provide, install, move, replace, maintain, clean, and remove all traffic control devices in accordance with the traffic control devices specifications and as shown on the plans and as directed. If details are not shown on the plans, provide devices and work in

accordance with the TMUTCD and as directed by the Engineer. When authorized or directed by the Engineer, provide additional signs or traffic control devices not required by the plans.

If an unexpected situation arises that causes the Contractor to believe that the traffic control should be changed, make all reasonable efforts to promptly contact the Engineer. Take prudent actions until the Engineer can be contacted.

The Engineer will make an inspection of the traffic control devices. Comply with the results of the inspection in the prescribed time frame.

- 2.1.1. **Contractor Responsible Person and Alternate.** Designate in writing, a Contractor's Responsible Person (CRP) and an alternate to be the representative of the Contractor who is responsible for taking or directing corrective measures regarding the traffic control. The CRP or alternate must be accessible by phone 24 hr. per day and able to respond when notified. The CRP and alternate must comply with the requirements of Section 7L.1.5.5., "Training."
- 2.1.2. **Flaggers.** Designate in writing, a flagger instructor who will serve as a flagging supervisor and is responsible for training and assuring that all flaggers are qualified to perform flagging duties. Before beginning work, provide a list of flaggers certified to perform flagging duties.
- Provide flaggers as directed. Flaggers must be courteous and able to effectively communicate with the public. When directing traffic, flaggers must dress appropriately, wear high-visibility safety apparel, use flags, signs, stop-slow paddles, and other hand-signaling devices, and follow the flagging procedures in the TMUTCD. Comply with the requirements of Section 7L.1.5.5., "Training."
- 2.1.3. **Law Enforcement Personnel.** Provide uniformed law enforcement personnel with patrol vehicles as directed. Document the work zone traffic services provided in the manner prescribed by the Department. Law enforcement personnel providing work zone traffic services must be trained for the service they perform. Comply with Section 7L.1.5.5., "Training."
- 2.1.4. **Other Work Zone Personnel.** Workers involved with traffic control, including the maintenance of the traffic control, must comply with the requirements of Section 7L.1.5.5., "Training."
- 2.1.5. **Training.** Workers involved with the traffic control must be trained using Department-approved training, except in the case of Section 7L.1.5.4, "Other Work Zone Personnel" who may be trained using Contractor-developed Training in lieu of Department-approved Training.

Provide a copy of the certification of completion to the Engineer, except in the case of Contractor-developed Training. Ensure the certification of completion includes the following:

- name of provider and course title,
- name of participant,
- date of completion, and
- date of expiration.

For Contractor developed-Training, maintain a log of attendees. Make the log available upon request. Ensure the log is legible and includes the following:

- print name and signature of participant,
- name and title of trainer, and
- date of training.

2. LAWS TO BE OBSERVED

Comply with all federal, state, and local laws, ordinances, and regulations that affect the performance of the work. Indemnify and save harmless the Owner and its representatives against any claim arising from violation by the Contractor of any law, ordinance, or regulation.

This Contract is between the Owner and the Contractor only. No person or entity may claim third-party beneficiary status under this Contract or any of its provisions, nor may any non-party sue for personal injuries or property damage under this Contract.

3. PERMITS, LICENSES, AND TAXES

Procure all permits and licenses; pay all charges, fees, and taxes; and give all notices necessary and incidental to the due and lawful prosecution of work, except for permits provided by the Owner and as specified in Article 7L.6., "Preservation of Cultural and Natural Resources and the Environment."

4. PATENTED DEVICES, MATERIAL, AND PROCESSES

Indemnify and save harmless the Owner from any claims for infringement from the Contractor's use of any patented design, device, material, process, trademark, or copyright selected by the Contractor and used in connection with the work. Indemnify and save harmless the Owner against any costs, expenses, or damages that it may be obliged to pay, by reason of this infringement, at any time during the prosecution or after the completion of the work.

5. PERSONAL LIABILITY OF PUBLIC OFFICIALS

Owner employees are agents and representatives of the Owner and will incur no liability, personal or otherwise, in carrying out the provisions of the Contract or in exercising any power or authority granted under the Contract.

6. PRESERVATION OF CULTURAL AND NATURAL RESOURCES AND THE ENVIRONMENT

If the Contractor initiates changes to the Contract and the Owner approves the changes, the Contractor is responsible for obtaining clearances and coordinating with the appropriate regulatory agencies.

Cultural Resources. Cease all work immediately if a site, building, or location of historical, archeological, educational, or scientific interest is discovered within the right of way. The site, building, or location will be investigated and evaluated by the Owner.

Texas Pollutant Discharge Elimination System (TPDES) Permits and Storm Water Pollution Prevention Plans (SWP3). The Contractor will file the Notice of Intent (NOI) and the Notice of Termination (NOT) for work shown on the plans in the right of way. Adhere to all requirements of the SWP3.

Work in Waters of the United States. For work in the right of way, the Owner will obtain any required Section 404 permits from the U.S. Army Corps of Engineers before work begins. Adhere to all agreements, mitigation plans, and standard best management practices required by the permit. When Contractor-initiated changes in the construction method changes the impacts to waters of the U.S., obtain new or revised Section 404 permits.

Work in Navigable Waters of the United States. For work in the right of way, the Owner will obtain any required Section 9 permits from the U.S. Coast Guard before work begins. Adhere to the stipulations of the permits and associated best management practices. When Contractor-initiated changes in the construction method changes the impacts to navigable waters of the U.S., obtain new or revised Section 9 permits.

Work Over the Recharge or Contributing Zone of Protected Aquifers. Make every reasonable effort to minimize the degradation of water quality resulting from impacts relating to work over the recharge or contributing zones of protected aquifers, as defined and delineated by the TCEQ. Use best management practices and perform work in accordance with Contract requirements.

Project-Specific Locations. For all project-specific locations (PSLs) on or off the right of way (material sources, waste sites, parking areas, storage areas, field offices, staging areas, haul roads, etc.), signing the

Contract certifies compliance with all applicable laws, rules, and regulations pertaining to the preservation of cultural resources, natural resources, and the environment as issued by the following or other agencies:

- Occupational Safety and Health Administration,
- Texas Commission on Environmental Quality,
- Texas Department of Transportation,
- Texas Historical Commission,
- Texas Parks and Wildlife Department,
- Texas Railroad Commission,
- U.S. Army Corps of Engineers,
- U.S. Department of Energy,
- U.S. Department of Transportation,
- U.S. Environmental Protection Agency,
- U.S. Federal Emergency Management Agency, and
- U.S. Fish and Wildlife Service.

All subcontractors must also comply with applicable environmental laws, rules, regulations, and requirements in the Contract. Maintain documentation of certification activities including environmental consultant reports, Contractor documentation on certification decisions and contacts, and correspondence with the resource agencies. Provide documentation upon request.

Obtain written approval from the Engineer for all PSLs in the right of way not specifically addressed on the plans. Prepare an SWP3 for all Contractor facilities, such as asphalt or concrete plants located within public right of way. Comply with all TCEQ permit requirements for portable facilities, such as concrete batch plants, rock crushers, asphalt plants, etc. Address all environmental issues, such as Section 404 permits, wetland delineation, endangered species consultation requirements, or archeological and historic site impacts. Obtain all permits and clearances in advance.

Contractor Responsibility. If the Contractor initiates changes to the Contract and the Owner approves the changes, the Contractor is responsible for obtaining clearances and coordinating with appropriate regulatory agencies.

7. AGRICULTURAL IRRIGATION

Regulate the sequence of work and make provisions as necessary to provide for agricultural irrigation or drainage during the work. Meet with the Irrigation District or land owner to determine the proper time and sequence when irrigation demands will permit shutting-off water flows to perform work.

Unless otherwise provided on the plans, the work performed under this article will not be measured or paid for directly but will be subsidiary to pertinent items.

8. SANITARY PROVISIONS

Provide and maintain adequate, neat, and sanitary toilet accommodations for employees, including Owner employees, in compliance with the requirements and regulations of the Texas Department of Health or other authorities with jurisdiction.

9. ABATEMENT AND MITIGATION OF EXCESSIVE OR UNNECESSARY NOISE

Minimize noise throughout all phases of the Contract. Exercise particular and special efforts to avoid the creation of unnecessary noise impact on adjacent noise sensitive receptors in the placement of non-mobile equipment such as air compressors, generators, pumps, etc. Place mobile and stationary equipment to cause the least disruption of normal adjacent activities.

All equipment associated with the work must be equipped with components to suppress excessive noise and these components must be maintained in their original operating condition considering normal depreciation.

Noise-attenuation devices installed by the manufacturer such as mufflers, engine covers, insulation, etc. must not be removed nor rendered ineffectual nor be permitted to remain off the equipment while the equipment is in use.

10. USING EXPLOSIVES

Do not endanger life or property. The contractor is required to submit a written Blasting Plan if required by the plans or requested by the Engineer. The Owner retains the right to reject the blasting plan. Store all explosives securely and clearly mark all storage places with "DANGER – EXPLOSIVES." Store, handle, and use explosives and highly flammable material in compliance with federal, state, and local laws, ordinances, and regulations. Assume liability for property damage, injury, or death resulting from the use of explosives.

Give at least a 48-hr. advance notice to the appropriate Road Master before doing any blasting work involving the use of electric blasting caps within 200 ft. of any railroad track.

11. RESPONSIBILITY FOR HAZARDOUS MATERIALS

Comply with the requirements of Article 6L.10., "Hazardous Materials." Indemnify and save harmless the Owner and its agents and employees from all suits, actions, or claims and from all liability and damages for any injury or damage to any person or property arising from the generation or disposition of hazardous materials introduced by the Contractor on any work done by the Contractor on Owner-owned or controlled sites. Indemnify and save harmless the Owner and its representatives from any liability or responsibility arising out of the Contractor's generation or disposition of any hazardous materials obtained, processed, stored, shipped, etc., on sites not owned or controlled by the Owner. Reimburse the Owner for all payments, fees, or restitution the Owner is required to make as a result of the Contractor's actions.

12. RESTORING SURFACES OPENED BY PERMISSION

Do not authorize anyone to make an opening in the highway for utilities, drainage, or any other reason without written permission by the Engineer. Repair all openings as directed by the Engineer. Payment for repair of surfaces opened by permission will be made in accordance with pertinent items or Article 4L.4., "Changes in the Work." Costs associated with openings made with Contractor authorization but without Owner approval will not be paid.

13. PROTECTING ADJACENT PROPERTY

Protect adjacent property from damage. If any damage results from an act or omission on the part of or on behalf of the Contractor, take corrective action to restore the damaged property to a condition similar or equal to that existing before the damage was done.

14. RESPONSIBILITY FOR DAMAGE CLAIMS

Indemnify and save harmless the Owner and its agents and employees from all suits, actions, or claims and from all liability and damages for any injury or damage to any person or property due to the Contractor's negligence in the performance of the work and from any claims arising or amounts recovered under any laws, including workers' compensation and the Texas Tort Claims Act. Indemnify and save harmless the Owner and assume responsibility for all damages and injury to property of any character occurring during the prosecution of the work resulting from any act, omission, neglect, or misconduct on the Contractor's part in the manner or method of executing the work; from failure to properly execute the work; or from defective work or material.

Pipelines and other underground installations that may or may not be shown on the plans may be located within the right of way. Indemnify and save harmless the Owner from any suits or claims resulting from damage by the Contractor's operations to any pipeline or underground installation. Make available the scheduled sequence of work to the respective utility owners so that they may coordinate and schedule adjustments of their utilities that conflict with the proposed work.

Comply with federal and state laws concerning legal gross and axle weights. Except for the designated Interstate system, vehicles with a valid yearly overweight tolerance permit may haul materials to the work locations at the permitted load. Provide copies of the yearly overweight tolerance permits to the Engineer upon request. Construction equipment is not exempt from oversize or overweight permitting requirements on roadways open to the traveling public.

Protect existing bridges and other structures that will remain in use by the traveling public during and after the completion of the Contract. Construction traffic on roadways, bridges, and culverts within the limits of the work, including any structures under construction that will remain in service during and after completion of the Contract is subject to legal size and weight limitations.

Additional temporary fill may be required by the Engineer for hauling purposes for the protection of certain structures. This additional fill will not be paid directly but will be subsidiary.

Replace or restore to original condition any structure damaged by the Contractor's operations.

The Engineer may allow equipment with oversize or non-divisible overweight loads to operate without a permit within the work locations on pavement structures not open to the traveling public. Submit Contractor-proposed changes to traffic control plans for approval, in accordance with Item 502, "Barricades, Signs, and Traffic Handling." The following sections further address overweight allowances. The Owner will make available to the Contractor any available plans and material reports for existing structures.

Overweight Construction Traffic Crossing Structures. The Engineer may allow crossing of a structure not open to the public within the work locations, when divisible or non-divisible loads exceed legal weight limitations, including limits for load-posted bridges. Obtain written permission to make these crossings. Submit for approval a structural analysis by a licensed professional engineer indicating that the excessive loads should be allowed. Provide a manufacturer's certificate of equipment weight that includes the weight distribution on the various axles and any additional parts such as counterweights, the configuration of the axles, or other information necessary for the analysis. Submit the structural analysis and supporting documentation sufficiently in advance of the move to allow for review. Permission may be granted if the Engineer finds that no damage or overstresses in excess of those normally allowed for occasional overweight loads will result to structures that will remain in use after Contract completion. Provide temporary matting or other protective measures as directed.

Schedule loads so that only one vehicle is on any span or continuous unit at any time. Use barricades, fences, or other positive methods to prevent other vehicular access to structures at any time the overweight load is on any span or continuous unit.

Construction Equipment Operating on Structures. Cranes and other construction equipment used to perform construction operations that exceed legal weight limits may be allowed on structures. Before any operation that may require placement of equipment on a structure, submit for approval a detailed structural analysis prepared by a licensed professional engineer.

Submit the structural analysis and supporting documentation sufficiently in advance of the use to allow for review and approval. Include all axle loads and configurations, spacing of tracks or wheels, tire loads, outrigger placements, center of gravity, equipment weight, and predicted loads on tires and outriggers for all planned movements, swings, or boom reaches. The analysis must demonstrate that no overstresses will occur in excess of those normally allowed for occasional overweight loads.

Loads on Structures. Do not store or stockpile material on bridge structures without written permission. If required, submit a structural analysis and supporting documentation by a licensed professional engineer for review. Permission may be granted if the Engineer finds that no damage or overstresses in excess of those normally allowed for occasional overweight loads will result to structures that will remain in use after Contract completion. Provide temporary matting or other protective measures as directed.

Hauling Divisible Overweight Loads on Pavement Within the Work Locations. The Engineer may allow divisible overweight loads on pavement structures within the work locations not open to the traveling public. Obtain written approval before hauling the overweight loads. Include calculations to demonstrate that there will be no damage or overstress to the pavement structure.

16.

CONTRACTOR'S RESPONSIBILITY FOR WORK

Until final acceptance of the Contract, take every precaution against injury or damage to any part of the work by the action of the elements or by any other cause, whether arising from the execution or from the nonexecution of the work. Protect all materials to be used in the work at all times, including periods of suspension.

When any roadway or portion of the roadway is in suitable condition for travel, it may be opened to traffic as directed. Opening of the roadway to traffic does not constitute final acceptance.

Repair damage to all work until final acceptance. Repair damage to existing facilities in accordance with the Contract or as directed. Repair damage to existing facilities or work caused by Contractor operations at the Contractor's expense. Repair work for damage that was not due to the Contractor's operations will not be paid for except as provided below.

Reimbursable Repair. Except for damage to appurtenances listed in Section 7L.16.2.1., "Unreimbursed Repair," the Contractor will be reimbursed for repair of damage caused by:

- motor vehicle, watercraft, aircraft, or railroad-train incident;
- vandalism; or
- Acts of God, such as earthquake, tidal wave, tornado, hurricane, or other cataclysmic phenomena of nature.

Appurtenances.

2.1.1.

Unreimbursed Repair. Except for destruction (not reusable) due to hurricanes, reimbursement will not be made for repair of damage to the following temporary appurtenances, regardless of cause:

- signs,
- barricades,
- changeable message signs, and
- other work zone traffic control devices.

Crash cushion attenuators and guardrail end treatments are the exception to the above listing and are to be reimbursed in accordance with Section 7L.16.2.2., "Reimbursed Repair."

For the devices listed in this section, reimbursement may be made for damage due to hurricanes. Where the Contractor retains replaced appurtenances after completion of the project, the Owner will limit the reimbursement to the cost that is above the salvage value at the end of the project.

2.1.2.

Reimbursed Repair. Reimbursement will be made for repair of damage due to the causes listed in Section 7L.16.1., "Reimbursable Repair," to appurtenances (including temporary and permanent crash cushion attenuators and guardrail end treatments).

Roadways and Structures. Until final acceptance, the Contractor is responsible for all work constructed under the Contract. The Owner will not reimburse the Contractor for repair work to new construction, unless the failure or damage is due to one of the causes listed in Section 7L.16.1., "Reimbursable Repair."

The Owner will be responsible for the cost for repair of damage to existing roadways and structures not caused by the Contractor's operations.

Detours. The Contractor will be responsible for the cost of maintenance of detours constructed under the Contract, unless the failure or damage is due to one of the causes listed in Section 7L.16.1., "Reimbursable

Repair.” The Engineer may consider failures beyond the Contractor’s control when determining reimbursement for repairs to detours constructed. The Owner will be responsible for the cost of maintenance of existing streets and roadways used for detours or handling traffic.

Relief from Maintenance. The Engineer may relieve the Contractor from responsibility of maintenance as outlined in this section. This relief does not release the Contractor from responsibility for defective materials or work or constitute final acceptance.

2.1.3. **Isolated Work Locations.** For isolated work locations, when all work is completed, including work for Article 5L.11., “Final Cleanup,” the Engineer may relieve the Contractor from responsibility for maintenance.

2.1.4. **Work Except for Vegetative Establishment and Test Periods.** When all work for all or isolated work locations has been completed, including work for Article 5L.11., “Final Cleanup,” with the exception of vegetative establishment and maintenance periods and test and performance periods, the Engineer may relieve the Contractor from responsibility for maintenance of completed portions of work.

2.1.5. **Work Suspension.** When all work is suspended for an extended period of time, the Engineer may relieve the Contractor from responsibility for maintenance of completed portions of work during the period of suspension.

2.1.6. **When Directed by the Engineer.** The Engineer may relieve the Contractor from the responsibility for maintenance when directed.

Basis of Payment. When reimbursement for repair work is allowed and performed, payment will be made in accordance with pertinent items or Article 4L.4., “Changes in the Work.”

17. ELECTRICAL REQUIREMENTS

Definitions.

2.1.1. **Electrical Work.** Electrical work is work performed for:

- Item 610, “Roadway Illumination Assemblies,”
- Item 614, “High Mast Illumination Assemblies,”
- Item 616, “Performance Testing of Lighting Systems,”
- Item 617, “Temporary Roadway Illumination,”
- Item 618, “Conduit,”
- Item 620, “Electrical Conductors,”
- Item 621, “Tray Cable,”
- Item 622, “Duct Cable,”
- Item 628, “Electrical Services,”
- Item 680, “Highway Traffic Signals,”
- Item 681, “Temporary Traffic Signals,”
- Item 684, “Traffic Signal Cables,”
- Item 685, “Roadside Flashing Beacon Assemblies,”
- other items that involve either the distribution of electrical power greater than 50 volts or the installation of conduit and duct banks,
- the installation of conduit and wiring associated with Item 624, “Ground Boxes,” and Item 656, “Foundations for Traffic Control Devices,” and
- the installation of the conduit system for communication and fiber optic cable.

Electrical work does not include the installation of communications or fiber optic cable, or the connections for low voltage and inherently power limited circuits such as electronic or communications equipment. Assembly and placement of poles, structures, cabinets, enclosures, manholes, or other hardware will not be considered electrical work as long as no wiring, wiring connections, or conduit work is done at the time of assembly and placement.

2.1.2. **Specialized Electrical Work.** Specialized electrical work is work that includes the electrical service and feeders, sub-feeders, branch circuits, controls, raceways, and enclosures for the following:

- pump stations,
- moveable bridges,
- ferry slips,
- motor control centers,
- facilities required under Item 504, "Field Office and Laboratory,"
- rest area or other public buildings,
- weigh-in-motion stations,
- electrical services larger than 200 amps,
- electrical services with main or branch circuit breaker sizes not shown in the Contract, and
- any 3-phase electrical power.

2.1.3. **Certified Person.** A certified person is a person who has passed the test from the TxDOT course TRF450, "TxDOT Roadway Illumination and Electrical Installations," or other courses as approved by the Owner. Submit a current and valid certification upon request.

2.1.4. **Licensed Electrician.** A licensed electrician is a person with a current and valid unrestricted master electrical license, or unrestricted journeyman electrical license that is supervised or directed by an unrestricted master electrician. An unrestricted master electrician need not be on the work locations at all times electrical work is being done, but the unrestricted master electrician must approve work performed by the unrestricted journeyman. Licensed electrician requirements by city ordinances do not apply to on state system work.

The unrestricted journeyman and unrestricted master electrical licenses must be issued by the Texas Department of Licensing and Regulation or by a city in Texas with a population of 50,000 or greater that issues licenses based on passing a written test and demonstrating experience.

The Engineer may accept other states' electrical licenses. Submit documentation of the requirements for obtaining that license. Acceptance of the license will be based on sufficient evidence that the license was issued based on:

- passing a test based on the NEC similar to that used by Texas licensing officials, and
- sufficient electrical experience commensurate with general standards for an unrestricted master and unrestricted journeyman electrician in the State of Texas.

Work Requirements. The qualifications required to perform electrical work and specialized electrical work are listed in Table 2.

Table 2
Work Requirements

Type of Work	Qualifications to Perform Work
Electrical work with plans	Licensed electrician, certified person, or workers directly supervised by a licensed electrician or certified person
Electrical work without plans	Licensed electrician or workers directly supervised by a licensed electrician
Specialized electrical work	Licensed electrician or workers directly supervised by a licensed electrician
Replace lamps, starting aids, and changing fixtures	Licensed electrician, certified person, or workers directly supervised by a licensed electrician or certified person
Conduit in precast section with approved working drawings	Inspection by licensed electrician or certified person
Conduit in cast-in-place section	Inspection by licensed electrician or certified person
All other electrical work (troubleshooting, repairs, component replacement, etc.)	Licensed electrician or workers directly supervised by a licensed electrician

“Directly supervised by a licensed electrician” means that a licensed electrician is physically present during all electrical work. “Directly supervised by a licensed electrician or certified person” means that a licensed electrician or certified person is physically present during all electrical work.

A non-certified person may install conduit in cast-in-place concrete sections if the work is verified by a certified person before concrete placement.

When the plans specify IMSA certification, the requirements of Table 2 will still apply to the installation of the conduit, ground boxes, electrical services, pole grounding, and electrical conductors installed under Item 620, “Electrical Conductors.”

18. PAYROLLS

Ensure that employees, contract labor, and any subcontractor’s employees are paid at least the predetermined wage rates shown on the Contract.

Payroll records must contain the information required by law. As an option, form WH-347, “Payroll” is provided by the U.S. Department of Labor.

Maintain payroll and related records during the course of the Contract and preserve these records for a period of 3 years following the completion of the Contract or as required by law.

Minimum Wage Requirements for Federally Funded Contracts. Comply with the requirements of FHWA-1723, “Required Contract Provisions Federal-Aid Construction Contract.”

Submit payroll records to the Engineer in the manner prescribed by the Owner.

Minimum Wage Requirements for State Funded Contracts. Comply with the requirements of 29 USC 206 unless otherwise shown in the Contract.

Upon request, submit payroll records to the Engineer in the manner prescribed by the Owner.

Item 8L

Prosecution and Progress



1. PROSECUTION OF WORK

Unless otherwise shown in the Contract, begin work within 30 calendar days after the authorization date to begin work as shown on the Notice to Proceed. Prosecute the work continuously to completion within the working days specified. Unless otherwise shown in the Contract documents, work may be prosecuted in concurrent phases if no changes are required in the traffic control plan or if a revised traffic control plan is approved. Notify the Engineer at least 24 hr. before beginning work or before beginning any new operation. Do not start new operations to the detriment of work already begun. Minimize interference to traffic.

2. SUBCONTRACTING

Do not sublet any portion of a construction Contract without the Engineer's written approval. A subcontract does not relieve any responsibility under the Contract and bonds. Ensure that all subcontracted work complies with all governing labor provisions.

The Contractor certifies by signing the Contract that the Contractor will not enter into any subcontract with a subcontractor that is debarred or suspended by the Owner, or any state or federal agency.

For federally funded Contracts, ensure the required federal documents are physically attached to each subcontract agreement including all tiered subcontract agreements.

For all DBE/HUB/SBE subcontracts including all tiered DBE/HUB/SBE subcontracts, submit a copy of the executed subcontract agreement.

Submit a copy of the executed non-DBE subcontracts including all tiered non-DBE subcontracts when requested.

Construction Contracts. Perform work with own organization on at least 30% of the total original Contract cost (25% if the Contractor is an SBE on a wholly State or local funded Contract) excluding any items determined by the Engineer to be specialty items. Specialty items are those that require highly specialized knowledge, abilities, or equipment not usually available in the contracting firm expected to bid on the proposed Contract as a whole.

Specialty items will be shown on the plans or as determined by the Engineer. Bid cost of specialty items performed by subcontractors will be deducted from the total original Contract cost before computing the required amount of work to be performed by the Contractor's own organization.

The term "perform work with own organization" includes only:

- workers employed and paid directly by the Contractor or wholly owned subsidiary;
- equipment owned by the Contractor or wholly owned subsidiary;
- rented or leased equipment operated by the Contractor's employees or wholly owned subsidiary's employees;
- materials incorporated into the work if the majority of the value of the work involved in incorporating the material is performed by the Contractor's own organization, including a wholly owned subsidiary's organization; and
- labor provided by staff leasing firms licensed under Chapter 91 of the Texas Labor Code for nonsupervisory personnel if the Contractor or wholly owned subsidiary maintains direct control over the activities of the leased employees and includes them in the weekly payrolls.

When staff leasing firms provide materials or equipment, they are considered subcontractors. In these instances, submit staff leasing firms for approval as a subcontractor.

Copies of cancelled checks and certified statements may be required to verify compliance with the requirements of this section.

Payments to Subcontractors. Report payments for DBE/HUB/SBE subcontracts including tiered DBE/HUB/SBE subcontracts in the manner as prescribed by the Owner.

Payment Records. Make payment records, including but not limited to copies of cancelled checks, available for inspection by the Owner. Submit payment records upon request. Retain payment records for a period of 3 years following completion of the Contract work or as specified by the Owner.

Failure to submit this information to the Engineer by the 20th day of each month will result in the Owner taking actions, including, but not limited to, withholding payments and suspending the work. This work will not be measured or paid for directly but will be subsidiary to pertinent items.

Payrolls. Comply with Article 7L.19., "Payrolls."

3. COMPUTATION OF CONTRACT TIME FOR COMPLETION

The number of working days is established by the Contract. Working day charges will begin as prescribed in Article 8L.1., "Prosecution of Work." Working day charges will continue in accordance with the Contract.

Upon request, the Engineer will provide the conceptual time determination schedule to the Contractor for informational purposes only. The schedules assume generic resources, production rates, sequences of construction and average weather conditions based on historic data. The Owner will not adjust the number of working days and milestones, if any, due to differences in opinion regarding any assumptions made in the preparation of the schedule or for errors, omissions, or discrepancies found in the Owner's conceptual time schedule.

Working Day Charges. Working days will be charged in accordance with Section 8L.3.1.4., "Standard Workweek," unless otherwise shown in the Contract documents. Working days will be computed and charged in accordance with one of the following:

- 2.1.1. **Five-Day Workweek.** Working days will be charged Monday through Friday, excluding national holidays, regardless of weather conditions or material availability. The Contractor has the option of working on Saturdays. Provide sufficient advance notice when scheduling work on Saturdays. Work on Sundays and national holidays will not be permitted without written permission. If work requiring an Inspector to be present is performed on a Saturday, Sunday, or national holiday, and weather and other conditions permit the performance of work for 7 hr. between 7 A.M. and 6 P.M., a working day will be charged.
- 2.1.2. **Six-Day Workweek.** Working days will be charged Monday through Saturday, excluding national holidays, regardless of weather conditions or material availability. Work on Sundays and national holidays will not be permitted without written permission. If work requiring an Inspector to be present is performed on a Sunday or a national holiday, and weather or other conditions permit the performance of work for 7 hr. between 7 A.M. and 6 P.M., a working day will be charged.
- 2.1.3. **Seven-Day Workweek.** Working days will be charged Monday through Sunday, excluding national holidays, regardless of weather conditions or material availability. Work on national holidays will not be permitted without written permission. If work is performed on any of these holidays requiring an Inspector to be present, and weather or other conditions permit the performance of work for 7 hr. between 7 A.M. and 6 P.M., a working day will be charged.
- 2.1.4. **Standard Workweek.** Working days will be charged Monday through Friday, excluding national or state holidays, if weather or other conditions permit the performance of the principal unit of work underway, as determined by the Engineer, for a continuous period of at least 7 hr. between 7 A.M. and 6 P.M., unless

otherwise shown in the Contract. The Contractor has the option of working on Saturdays or state holidays. Provide sufficient advance notice to the Engineer when scheduling work on Saturdays. Work on Sundays and national holidays will not be permitted without written permission. If work requiring an Inspector to be present is performed on a Saturday, Sunday, or holiday, and weather or other conditions permit the performance of work for 7 hr. between 7 A.M. and 6 P.M., a working day will be charged.

2.1.5. **Calendar Day.** Working days will be charged Sunday through Saturday, including all holidays, regardless of weather conditions, material availability, or other conditions not under the control of the Contractor.

2.1.6. **Other.** Working days will be charged as shown in the Contract documents.

Restricted Work Hours. Restrictions on Contractor work hours and the related definition for working day charges are as prescribed in this article unless otherwise shown in the Contract documents.

Nighttime Work. Nighttime work is allowed only when shown in the Contract documents or as directed. Nighttime work is defined as work performed from 30 min. after sunset to 30 min. before sunrise.

2.1.7. **Five-, Six-, and Seven-Day Workweeks.** Nighttime work that extends past midnight will be assigned to the following day for the purposes of approval for allowing work on Sundays or national holidays.

2.1.8. **Standard Workweek.**

2.1.8.1. **Nighttime Work Only.** When nighttime work is allowed or required and daytime work is not allowed, working day charges will be made when weather and other conditions permit the performance of the principal unit of work underway, as determined by the Engineer, for a continuous period of at least 7 hr. for the nighttime period, as defined in Section 8L.3.3., "Nighttime Work," unless otherwise shown in the Contract documents.

2.1.8.2. **Nighttime Work and Daytime Work Requiring Inspector.** When nighttime work is performed or required and daytime work is allowed, working day charges will be made when weather and other conditions permit the performance of the principal unit of work underway, as determined by the Engineer, for a continuous period of at least 7 hr. for the nighttime period, as defined in Section 8L.3.3., "Nighttime Work," or for a continuous period of at least 7 hr. for the alternative daytime period unless otherwise shown in the Contract documents. Only one day will be charged for each 24-hr. time period. When the Engineer agrees to restrict work hours to the nighttime period only, working day charges will be in accordance with Section 8L.3.3.2.1., "Nighttime Work Only."

Time Statements. The Engineer will furnish the Contractor a monthly time statement. Review the monthly time statement for correctness. Report protests in writing, no later than 30 calendar days after receipt of the time statement, providing a detailed explanation for each day protested. Not filing a protest within 30 calendar days will indicate acceptance of the working day charges and future consideration of that statement will not be permitted.

4. TEMPORARY SUSPENSION OF WORK OR WORKING DAY CHARGES

The Engineer may suspend the work, wholly or in part, and will provide notice and reasons for the suspension in writing. Suspend and resume work only as directed in writing.

When part of the work is suspended, the Engineer may suspend working day charges only when conditions not under the control of the Contractor prohibit the performance of critical activities. When all of the work is suspended for reasons not under the control of the Contractor, the Engineer will suspend working day charges.

5. PROJECT SCHEDULES

Prepare, maintain, and submit project schedules. Project schedules are used to convey the Contractor's intended work plan to the Owner. Prepare project schedules with a level of effort sufficient for the work being

performed. Project schedules will not be used as a basis to establish the amount of work performed or for the preparation of the progress payments.

Project Scheduler. Designate an individual who will develop and maintain the progress schedule. The Project Scheduler will be prepared to discuss, in detail, the proposed sequence of work and methods of operation, and how that information will be communicated through the Progress Schedule at the Preconstruction Meeting. This individual will also attend the project meetings and make site visits to prepare, develop, and maintain the progress schedules.

Progress Schedule. Before starting work, prepare and submit a progress schedule based on the sequence of work and traffic control plan shown in the Contract documents. At a minimum, prepare the progress schedule as a Bar Chart or Critical Path Method (CPM), as shown on the plans. Include all planned work activities and sequences and show Contract completion within the number of working days specified. Incorporate major material procurements, known utility relocations, and other activities that may affect the completion of the Contract in the progress schedule. Show a beginning date, ending date, and duration in whole working days for each activity. Do not use activities exceeding 20 working days, except for agreed upon activities. Show an estimated production rate per working day for each work activity.

Schedule Format. Format all project schedules according to the following:

- Begin the project schedule on the date of the start of Contract time or start of activities affecting work on the project;
- Show the sequence and interdependence of activities required for complete performance of the work. If using a CPM schedule, show a predecessor and a successor for each activity; and
- Ensure all work sequences are logical and show a coordinated plan of the work.

CPM schedules must also include:

- Clearly and accurately identify the critical path as the longest continuous path;
- Provide a legend for all abbreviations, run date, data date, project start date, and project completion date in the title block of each schedule submittal; and
- Through the use of calendars, incorporate seasonal weather conditions into the schedule for work (e.g., earthwork, concrete paving, structures, asphalt, drainage, etc.) that may be influenced by temperature or precipitation. Also, incorporate non-work periods such as holidays, weekends, or other non-work days as identified in the Contract.

Activity Format. For each activity on the project schedule provide:

- A concise description of the work represented by the activity;
- An activity duration in whole working days;
- Code activities so that organized plots of the schedule may be produced.

CPM schedules must also include the quantity of work and estimated production rate for major items of work. Provide enough information for review of the work being performed.

Schedule Types.

- 2.1.1. **Bar Chart.** Seven calendar days before the preconstruction meeting, prepare and submit a hard copy of the schedule using the bar chart method.
- 2.1.1.1. **Progress Schedule Reviews.** Update the project schedule and submit a hard copy when changes to the schedule occur or when requested.
- 2.1.2. **Critical Path Method.** Prepare and submit the schedule using the CPM.
- 2.1.2.1. **Preliminary Schedule.** Seven calendar days before the preconstruction meeting, submit both the plotted and electronic copies of the project schedule showing work to be performed within the first 90 calendar days of the project.

- 2.1.2.2. **Baseline Schedule.** The baseline schedule will be considered the Contractor's plan to successfully construct the project within the time frame and construction sequencing indicated in the Contract. Submit both plotted and electronic copies of the baseline schedule. Submit 2 plots of the schedule: one organized with the activities logically grouped using the activity coding; and the other plot showing only the critical path determined by the longest path, not based on critical float.

Develop and submit the baseline schedule for review within the first 45 calendar days of the project unless the time for submission is extended.

- 5.5.2.2.1. **Review.** Within 15 calendar days of receipt of the schedule, the Engineer will evaluate, and inform the Contractor if the schedule has been accepted. If the schedule is not accepted, the Engineer will provide comments to the Contractor for incorporation. Provide a revised schedule based on the Engineer's comments, or reasons for not doing so within 10 calendar days. The Engineer's review and acceptance of the project schedule is for conformance to the requirements of the Contract documents only and does not relieve the Contractor of any responsibility for meeting the interim milestone dates (if specified) or the Contract completion date. Review and acceptance does not expressly or by implication warrant, acknowledge, or admit the reasonableness of the logic or durations of the project schedule. If the Contractor fails to define any element of work, activity, or logic and the Engineer's review does not detect this omission or error, the Contractor is responsible for correcting the error or omission.

Submit an acceptable baseline schedule before the 90th calendar day of the project unless the time for submission is extended.

- 2.1.2.3. **Progress Schedule.** Maintain the project schedule for use by both the Contractor and the Engineer. Submit both the plotted and electronic copy as it will become an as-built record of the daily progress achieved on the project. If continuous progress of an activity is interrupted for any reason except non-work periods (such as holidays, weekend, or interference from temperature or precipitation), then the activity will show the actual finish date as that date of the start of the interruption and the activity will be broken into a subsequent activity (or activities, based on the number of interruptions) similarly numbered with successive alpha character as necessary. The original duration of the subsequent activity will be that of the remaining duration of the original activity. Relationships of the subsequent activity will match those of the original activity so that the integrity of the project schedule logic is maintained. Once established, the original durations and actual dates of all activities must remain unchanged. Revisions to the schedule may be made as necessary.

The project schedule must be revised when changes in construction phasing and sequencing occur or other changes that cause deviation from the original project schedule occur. Any revisions to the schedule must be listed in the monthly update narrative with the purpose of the revision and description of the impact on the project schedule's critical path and project completion date. Create the schedule revision using the latest update before the start of the revision.

Monthly updating of the project schedule will include updating of:

- The actual start dates for activities started;
- The actual finish dates for activities completed;
- The percentage of work completed and remaining duration for each activity started but not yet completed; and
- The calendars to show days actual work was performed on the various work activities.

The cut-off day for recording monthly progress will be the last day of each month. Submit the updated project schedule no later than the 20th calendar day of the following month. The Engineer will evaluate the updated schedule within 5 calendar days of receipt and inform the Contractor if it has or has not been accepted. If the schedule is not accepted, the Engineer will provide comments to the Contractor for incorporation. Provide a revised schedule based on the Engineer's comments, or reasons for not doing so within 5 calendar days.

Provide a brief narrative in a bulleted statement format for major items that have impacted the schedule. Notify the Engineer if resource-leveling is being used.

5.5.2.3.1. **Project Schedule Summary Report (PSSR).** When shown on the plans, provide the PSSR instead of the narrative required in Section 8L.5.5.2.3., "Progress Schedule." The PSSR includes a listing of major items that have impacted the schedule as well as a summary of progress in days ahead or behind schedule. Include an explanation of the project progress for the period represented on the form provided by the Owner.

2.1.3. **Notice of Potential Time Impact.** Submit a "Notice of Potential Time Impact" when a Contract time extension or adjustment of milestone dates may be justified or when directed.

Failure to provide this notice in the time frames outlined above will compromise the Owner's ability to mitigate the impacts and the Contractor forfeits the right to request a time extension or adjustment of milestone dates unless the circumstances are such that the Contractor could not reasonably have had knowledge of the impact at the time.

2.1.4. **Time Impact Analysis.** When directed, provide a time impact analysis. A time impact analysis is an evaluation of the effects of impacts on the project. A time impact analysis consists of the following steps:

- **Step 1.** Establish the status of the project immediately before the impact.
- **Step 2.** Predict the effect of the impact on the schedule update used in Step 1.
- **Step 3.** Track the effects of the impact on the schedule during its occurrence.
- **Step 4.** Establish the status of the project after the impact's effect has ended and provide details identifying any mitigating actions or circumstances used to keep the project ongoing during the impact period.

Determine the time impact by comparing the status of the work before the impact (Step 1) to the prediction of the effect of the impact (Step 2), if requested, and to actual effects of the impact once it is complete (Step 4). Unless otherwise approved, Steps 1, 3, and 4, must be completed before consideration of a Contract time extension or adjustment of a milestone date will be provided. Time extensions will only be considered when delays that affect milestone dates or the Contract completion date are beyond the Contractor's control. Submit Step 4 no later than 15 calendar days after the impact's effects have ended or when all the information on the effect has been realized.

Submit one electronic backup copy of the complete time impact analysis and a copy of the full project schedule incorporating the time impact analysis. If the project schedule is revised after the submittal of a time impact analysis, but before its approval, indicate in writing the need for any modification to the time impact analysis.

The Engineer will review the time impact analysis upon completion of step 4. If this review detects revisions or changes to the schedule that had not been performed and identified in a narrative, the Engineer may reject the time impact analysis. If the Engineer is in agreement with the time impact analysis, a change order may be issued to grant additional working days, or to adjust interim milestones. Once a change order has been executed, incorporate the time impact analysis into the project schedule. The time impact analysis may also be used to support the settlement of disputes and claims. Compensation related to the time impact analysis may be provided at the completion of the analysis or the completion of the project to determine the true role the impact played on the final completion.

The work performed under this article will not be measured or paid for directly but will be subsidiary to pertinent items.

6. FAILURE TO COMPLETE WORK ON TIME

The time established for the completion of the work is an essential element of the Contract. If the Contractor fails to complete the work within the number of working days specified, working days will continue to be charged. Failure to complete the Contract, a separate work order, or callout work within the number of working days specified, including any approved additional working days, will result in liquidated damages for each working day charged over the number of working days specified in the Contract. The dollar amount specified in the Contract will be deducted from any money due or to become due the Contractor for each

working day the Contract remains incomplete. This amount will be assessed not as a penalty but as liquidated damages.

7. DEFAULT OF THE CONTRACT

Declaration of Default. The Engineer may declare the Contractor to be in default of the Contract if the Contractor:

- fails to begin the work within the number of days specified,
- fails to prosecute the work to assure completion within the number of days specified,
- is uncooperative, disruptive or threatening,
- fails to perform the work in accordance with the Contract requirements,
- neglects or refuses to remove and replace rejected materials or unacceptable work,
- discontinues the prosecution of the work without the Engineer's approval,
- makes an unauthorized assignment,
- fails to resume work that has been discontinued within a reasonable number of days after notice to do so,
- fails to conduct the work in an acceptable manner, or
- commits fraud or other unfixable conduct as determined by the Owner.

If any of these conditions occur, the Engineer will give notice in writing to the Contractor and the Surety of the intent to declare the Contractor in default. If the Contractor does not proceed as directed within 10 days after the notice, the Owner will provide written notice to the Contractor and the Surety to declare the Contractor to be in default of the Contract. The Owner will also provide written notice of default to the Surety. If the Contractor provides the Owner written notice of voluntary default of the Contract, the Owner may waive the 10-day notice of intent to declare the Contractor in default and immediately provide written notice of default to the Contractor and the Surety. Working day charges will continue until completion of the Contract. The Owner may suspend work in accordance with Section 8L.4., "Temporary Suspension of Work or Working Day Charges," to investigate apparent fraud or other unfixable conduct before defaulting the Contractor. The Contractor may be subject to sanctions under the state and/or federal laws and regulations.

The Owner will determine the method used for the completion of the remaining work as follows:

- **Contracts without Performance Bonds.** The Owner will determine the most expeditious and efficient way to complete the work, and recover damages from the Contractor.
- **Contracts with Performance Bonds.** The Owner will, without violating the Contract, demand that the Contractor's Surety complete the remaining work in accordance with the terms of the original Contract. A completing Contractor will be considered a subcontractor of the Surety. The Owner reserves the right to approve or reject proposed subcontractors. Work may resume after the Owner receives and approves Certificates of Insurance as required in Section 3.4.3., "Insurance." Certificates of Insurance may be issued in the name of the completing Contractor. The Surety is responsible for making every effort to expedite the resumption of work and completion of the Contract. The Owner may complete the work using any or all materials at the work locations that it deems suitable and acceptable. Any costs incurred by the Owner for the completion of the work under the Contract will be the responsibility of the Surety.

From the time of notification of the default until work resumes (either by the Surety or the Owner), the Owner will maintain traffic control devices and will do any other work it deems necessary, unless otherwise agreed upon by the Owner and the Surety. All costs associated with this work will be deducted from money due to the Surety.

The Owner will hold all money earned but not disbursed by the date of default. Upon resumption of the work after the default, all payments will be made to the Surety. All costs and charges incurred by the Owner as a result of the default, including the cost of completing the work under the Contract, costs of maintaining traffic control devices, costs for other work deemed necessary, and any applicable liquidated damages or disincentives will be deducted from money due the Contractor for completed work. If these costs exceed the sum that would have been payable under the Contract, the Surety will be liable and pay the Owner the

balance of these costs in excess of the Contract price. In case the costs incurred by the Owner are less than the amount that would have been payable under the Contract if the work had been completed by the Contractor, the Owner will be entitled to retain the difference.

Comply with Article 8L.2., "Subcontracting," and abide by the DBE/HUB/SBE commitments previously approved by the Owner.

No markups as defined in Article 9L.7., "Payment for Extra Work and Force Account Method," will be allowed for the Surety.

Wrongful Default. Submit a written request to the Owner within 14 calendar days of receipt of the notice of default for consideration of wrongful default.

The Owner will determine if the Contractor has been wrongfully defaulted, and will proceed with the following:

- If the Owner determines the default is proper, the default will remain. If the Contractor is in disagreement, the Contractor may file a claim in accordance with Article 4L.7., "Dispute or Claims Procedure."
- If the Owner determines it was a wrongful default, the Owner will terminate the Contract for convenience, in accordance with Article 8L.8., "Termination of the Contract."

8. TERMINATION OF THE CONTRACT

The Owner may terminate the Contract in whole or in part whenever:

- the Contractor is prevented from proceeding with the work as a direct result of an executive order of the President of the United States or the Governor of the State;
- the Contractor is prevented from proceeding with the work due to a national emergency, or when the work to be performed under the Contract is stopped, directly or indirectly, because of the freezing or diversion of materials, equipment or labor as the result of an order or a proclamation of the President of the United States;
- the Contractor is prevented from proceeding with the work due to an order of any federal authority;
- the Contractor is prevented from proceeding with the work by reason of a preliminary, special, or permanent restraining court order where the issuance of the restraining order is primarily caused by acts or omissions of persons or agencies other than the Contractor; or
- the Owner determines that termination of the Contract is in the best interest of the Owner or the public. This includes, but is not limited to, the discovery of significant hazardous material problems, right of way acquisition problems, or utility conflicts that would cause substantial delays or expense to the Contract.

Procedures and Submittals. The Engineer will provide written notice to the Contractor of termination specifying the extent of the termination and the effective date. Upon notice, immediately proceed in accordance with the following:

- stop work as specified in the notice;
- place no further subcontracts or orders for materials, services, or facilities, except as necessary to complete a critical portion of the Contract, as approved;
- terminate all subcontracts to the extent they relate to the work terminated;
- complete performance of the work not terminated;
- settle all outstanding liabilities and termination settlement proposals resulting from the termination for public convenience of the Contract;
- create an inventory report, including all acceptable materials and products obtained for the Contract that have not been incorporated in the work that was terminated (include in the inventory report a description, quantity, location, source, cost, and payment status for each of the acceptable materials and products); and

- take any action necessary, or that the Engineer may direct, for the protection and preservation of the materials and products related to the Contract that are in the possession of the Contractor and in which the Owner has or may acquire an interest.

Settlement Provisions. Within 60 calendar days of the date of the notice of termination, submit a final termination settlement proposal, unless otherwise approved. The Engineer will prepare a change order that reduces the affected quantities of work and adds acceptable costs for termination. No claim for loss of anticipated profits will be considered. The Owner will pay reasonable and verifiable termination costs including:

- all work completed at the unit bid price and partial payment for incomplete work;
- the percentage of Item 500, "Mobilization," equivalent to the percentage of work complete or actual cost that can be supported by cost records, whichever is greater;
- expenses necessary for the preparation of termination settlement proposals and support data;
- the termination and settlement of subcontracts;
- storage, transportation, restocking, and other costs incurred necessary for the preservation, protection, or disposition of the termination inventory; and
- other expenses acceptable to the Owner.

Item 9L

Measurement and Payment



1. MEASUREMENT OF QUANTITIES

The Engineer will measure all completed work using United States standard measures, unless otherwise specified.

Linear Measurement. Unless otherwise specified, all longitudinal measurements for surface areas will be made along the actual surface of the roadway and not horizontally. No deduction will be made for structures in the roadway with an area of 9 sq. ft. or less. For all transverse measurements for areas of base courses, surface courses, and pavements, the dimensions to be used in calculating the pay areas will be the neat dimensions and will not exceed those shown on the plans, unless otherwise directed.

Volume Measurement. Transport materials measured for payment by volume in approved hauling vehicles. Display a unique identification mark on each vehicle. Furnish information necessary to calculate the volume capacity of each vehicle. The Engineer may require verification of volume through weight measurement. Use body shapes that allow the capacity to be verified. Load and level the load to the equipment's approved capacity. Loads not hauled in approved vehicles may be rejected.

Weight Measurement. Transport materials measured for payment by weight or truck measure in approved hauling vehicles. Furnish certified measurements, tare weights, and legal gross weight calculations for all haul units. Affix a permanent, legible number on the truck and on the trailer to correspond with the certified information. Furnish certified weights of loaded haul units transporting material if requested.

The material will be measured at the point of delivery. The cost of supplying these volume and weight capacities is subsidiary to the pertinent item. For measurement by the ton, in the field, provide measurements in accordance with Item 520, "Weighing and Measuring Equipment," except for items where ton measurements are measured by standard tables.

The Engineer may reject loads and suspend hauling operations for overloading.

2.1.1. **Hauling on Routes Accessible to the Traveling Public.** For payment purposes on haul routes accessible to the traveling public, the net weight of the load will be calculated as follows:

- If the gross vehicle weight is less than the maximum allowed by state law, including applicable yearly weight tolerance permit, the net weight of the load will be determined by deducting the tare weight of the vehicle from the gross weight.
- If the gross vehicle weight is more than the maximum allowed by state law, including applicable yearly weight tolerance permit, the net weight of the load will be determined by deducting the tare weight of the vehicle from the maximum gross weight allowed.

2.1.2. **Hauling on Routes Not Accessible to the Traveling Public.** For payment purposes on haul routes that are not accessible to the traveling public where advance permission is obtained in writing from the Engineer:

- If the gross vehicle weight is less than the maximum allowed, including applicable yearly weight tolerance permit, the net weight of the load will be determined by deducting the tare weight of the vehicle from the gross weight.
- If the gross vehicle weight is more than the maximum allowed, the net weight of the load will be determined by deducting the tare weight of the vehicle from the maximum gross weight allowed.

2. PLANS QUANTITY MEASUREMENT

Plans quantities may or may not represent the exact quantity of work performed or material moved, handled, or placed during the execution of the Contract. The estimated bid quantities are designated as final payment quantities, unless revised by the governing specifications or this article.

If the quantity measured as outlined under "Measurement" varies by more than 5% (or as stipulated under "Measurement" for specific Items) from the total estimated quantity for an individual item originally shown in the Contract, an adjustment may be made to the quantity of authorized work done for payment purposes.

When quantities are revised by a change in design approved by the Owner, by change order, or to correct an error on the plans, the plans quantity will be increased or decreased by the amount involved in the change, and the 5% variance will apply to the new plans quantity.

If the total Contract quantity multiplied by the unit bid price for an individual item is less than \$250 and the item is not originally a plans quantity item, then the item may be paid as a plans quantity item if the Engineer and Contractor agree in writing to fix the final quantity as a plans quantity.

For Contracts with callout work and work orders, plans quantity measurement requirements are not applicable.

3. ADJUSTMENT OF QUANTITIES

The party to the Contract requesting the adjustment will provide field measurements and calculations showing the revised quantity. When approved, this revised quantity will constitute the final quantity for which payment will be made. Payment for revised quantity will be made at the unit price bid for that item, except as provided for in Article 4L.4., "Changes in the Work."

4. SCOPE OF PAYMENT

Payment of the Contract unit price is full compensation for all materials, equipment, labor, tools, and supplies necessary to complete the item of work under the Contract. Until final acceptance in accordance with Article 5L.12., "Final Acceptance," assume liability for completing the work according to the Contract documents and any loss or damage arising from the performance of the work or from the action of the elements, infringement of patent, trademark, or copyright, except as provided elsewhere in the Contract.

The Owner will only pay for material incorporated into the work in accordance with the Contract. Payment of progress estimates will in no way affect the Contractor's obligation under the Contract to repair or replace any defective parts in the construction or to replace any defective materials used in the construction and to be responsible for all damages due to defects if the defects and damages are discovered on or before final inspection and acceptance of the work.

5. PROGRESS PAYMENTS

The Engineer will prepare a monthly estimate of the amount of work performed, including materials in place. Incomplete items of work may be paid at an agreed upon percentage as approved. Payment of the monthly estimate is determined at the Contract item prices less any withholdings or deductions in accordance with the Contract. Progress payments may be withheld for failure to comply with the Contract.

6. PAYMENT FOR MATERIAL ON HAND (MOH)

If payment for MOH is desired, request compensation for the invoice cost of acceptable nonperishable materials that have not been used in the work before the request, and that have been delivered to the work location or are in acceptable storage places. Nonperishable materials are those that do not have a shelf life or whose characteristics do not materially change when exposed to the elements. Include only materials that

have been sampled, tested, approved, or certified, and are ready for incorporation into the work. Only materials which are completely constructed or fabricated on the Contractor's order for a specific Contract and are so marked and on which an approved test report has been issued are eligible. Payment for MOH may include the following types of items: concrete traffic barrier, precast concrete box culverts, concrete piling, reinforced concrete pipe, and illumination poles. Any repairs required after fabricated materials have been approved for storage will require approval of the Engineer before being made and will be made at the Contractor's expense. Include only those materials that have an invoice cost of at least \$1,000 in the request for MOH payment.

If the request is acceptable, the Engineer will include payment for MOH in a progress payment. Payment for MOH does not constitute acceptance of the materials. Payment will not exceed the actual cost of the material as established by invoice, or the total cost for the associated item less reasonable placement costs, whichever is less. Materials for which the Contractor does not have a paid invoice within 60 days will not be eligible for payment and will be removed from the estimate. Payment may be limited to a portion of the invoice cost or unit price if shown elsewhere in the Contract. Payment for precast products fabricated or constructed by the Contractor for which invoices or freight bills are not available may be made based on statements of actual cost.

Submit the request on forms provided by the Owner. These forms may be electronically reproduced, provided they are in the same format and contain all the required information and certifications. Continue to submit monthly MOH forms until the total value of MOH is \$0.

By submitting a request for MOH payment, the Contractor expressly authorizes the Owner to audit MOH records, and to perform process reviews of the record-keeping system. If the Owner determines noncompliance with any of the requirements of this provision, the Owner may exclude payment for any or all MOH for the duration of the Contract.

Maintain all records relating to MOH payment until final acceptance. Provide these records to the Engineer upon request.

7. PAYMENT FOR EXTRA WORK AND FORCE ACCOUNT METHOD

Payment for extra work directed, performed, and accepted will be made in accordance with Article 4L.4., "Changes in the Work." Payment for extra work may be established by agreed unit prices or by Force Account Method.

Agreed unit prices are unit prices that include markups and are comparable to recent bid prices for the same character of work. These unit prices may be established without additional breakdown justification.

When using Force Account Method, determine an estimated cost for the proposed work and establish labor and equipment rates and material costs. Maintain daily records of extra work and provide copies of these records daily, signed by the Contractor's representative, for verification by the Engineer. Request payment for the extra work no later than the 10th day of the month following the month in which the work was performed. Include copies of all applicable invoices. If the extra work to be performed has an estimated cost of less than \$10,000, submit for approval and payment an invoice of actual cost for materials, equipment, labor, tools, and incidentals necessary to complete the extra work.

Markups. Payment for extra work may include markups as compensation for the use of small tools, overhead expense, and profit.

- 2.1.1. **Labor.** Compensation will be made for payroll rates for each hour that the labor, foremen, or other approved workers are actually engaged in the work. In no case will the rate of wages be less than the minimum shown in the Contract for a particular category. An additional 25% of this sum will be paid as compensation for overhead, superintendence, profit, and small tools.

- 2.1.2. **Insurance and Taxes.** An additional 55% of the labor cost, excluding the 25% compensation provided in Section 9L.7.1.1., "Labor," will be paid as compensation for labor insurance and labor taxes including the

cost of premiums on non-project-specific liability (excluding vehicular) insurance, workers compensation insurance, Social Security, unemployment insurance taxes, and fringe benefits.

2.1.3. **Materials.** Compensation will be made for materials associated with the work based on actual delivered invoice costs, less any discount. An additional 25% of this sum will be paid as compensation for overhead and profit.

2.1.4. **Equipment.** Payment will be made for the established equipment hourly rates for each hour that the equipment is involved in the work. An additional 15% of this sum will be paid as compensation for overhead and profit not included in the rates.

Transportation cost for mobilizing equipment will be included if the equipment is mobilized from an off-site location.

2.1.4.1. **Contractor-Owned Equipment.** For Contractor-owned machinery, trucks, power tools, or other equipment, use the FHWA rental rates found in the *Rental Rate Blue Book* multiplied by the regional adjustment factor and the rate adjustment factor to establish hourly rates. Use the rates in effect for each section of the *Rental Rate Blue Book* at the time of use.

If a rate has not been established for a particular piece of equipment in the *Rental Rate Blue Book*, the Engineer will allow a reasonable hourly rate. This price will include operating costs.

Payment for equipment will be made for the actual hours used in the work. The Owner reserves the right to withhold payment for low production or lack of progress. Payment will not be made for time lost for equipment breakdowns, time spent to repair equipment, or time after equipment is no longer needed.

If equipment is used intermittently while dedicated solely to the work, payment will be made for the duration the equipment is assigned to the work but no more than 8 hours will be paid during a 24-hour day, nor more than 40 hours per week, nor more than 176 hours per month, except when time is computed using a six-day or seven-day workweek. When using a six-day workweek, no more than 8 hours will be paid during a 24-hour day, nor more than 48 hours per week, nor more than 211 hours per month. When using a seven-day workweek, no more than 8 hours will be paid during a 24-hour day, nor more than 56 hours per week, nor more than 246 hours per month.

2.1.4.2. **Equipment Not Owned by the Contractor.** For equipment rented from a third party not owned by the Contractor, payment will be made at the invoice daily rental rate for each day the equipment is needed for the work. The Owner reserves the right to limit the daily rate to comparable *Rental Rate Blue Book* rates. When the invoice specifies that the rental rate does not include fuel, lubricants, repairs, and servicing, the *Rental Rate Blue Book* hourly operating cost for each hour the equipment is operated will be added.

When the invoice specifies equipment operators as a component of the equipment rental, payment will be made at the invoice rate for each operator for each day the equipment is needed for the work.

2.1.4.3. **Standby Equipment Costs.** Payment for standby equipment will be made in accordance with Section 9L.7.1.4., "Equipment," except that:

7.1.4.3.1. **Contractor-Owned Equipment.** For Contractor-owned machinery, trucks, power tools, or other equipment:

- Standby will be paid at 50% (to remove operating cost) of the FHWA rental rates found in the *Rental Rate Blue Book* multiplied by the regional adjustment factor and the rate adjustment factor.
- Standby costs will not be allowed during periods when the equipment would have otherwise been idle.

7.1.4.3.2. **Equipment Not Owned by the Contractor.** For equipment rented from a third party not owned by the Contractor:

- Standby will be paid at the invoice daily rental rate, excluding operating cost, which includes fuel, lubricants, repairs, and servicing. The Owner reserves the right to limit the daily standby rate to

comparable FHWA rental rates found in the *Rental Rate Blue Book* multiplied by the regional adjustment factor and the rate adjustment factor.

- Standby will be paid for equipment operators when included on the invoice and equipment operators are actually on standby.
- Standby costs will not be allowed during periods when the equipment would have otherwise been idle.

- 2.1.5. **Subcontracting.** An additional 5% of the actual invoice cost will be paid to the Contractor as compensation for administrative cost, superintendence, and profit.
- 2.1.6. **Law Enforcement.** An additional 5% of the actual invoice cost will be paid as compensation for administrative costs, superintendence, and profit.
- 2.1.7. **Railroad Flaggers.** An additional 5% of the actual invoice cost will be paid as compensation for administrative cost, superintendence, and profit.
- 2.1.8. **Bond Cost.** An additional 1% of the total compensation provided in Article 9L.7., "Payment for Extra Work and Force Account Method," will be paid for the increase in bond.

8. RETAINAGE

The Owner will not withhold retainage on the Contractor. The Contractor may withhold retainage on subcontractors in accordance with state and federal regulations.

9. PAYMENT PROVISIONS FOR SUBCONTRACTORS

For the purposes of this article only, the term subcontractor includes suppliers, and the term work includes materials provided by suppliers at a location approved by the Engineer.

These requirements apply to all tiers of subcontractors. Incorporate the provisions of this article into all subcontract or material purchase agreements.

Pay subcontractors for work performed within 10 days after receiving payment for the work performed by the subcontractor. Also, pay any retainage on a subcontractor's work within 10 days after satisfactory completion of all of the subcontractor's work. Completed subcontractor work includes vegetative establishment, test, maintenance, performance, and other similar periods that are the responsibility of the subcontractor.

For the purpose of this section, satisfactory completion is accomplished when:

- the subcontractor has fulfilled the Contract requirements of both the Owner and the subcontract for the subcontracted work, including the submittal of all information required by the specifications and the Owner; and
- the work done by the subcontractor has been inspected, approved, and paid by the Owner.

Provide a certification of prompt payment in accordance with the Owner's prompt payment procedure to certify that all subcontractors and suppliers were paid from the previous months payments and retainage was released for those whose work is complete. Submit the completed form each month and the month following the month when final acceptance occurred at the end of the project.

The inspection and approval of a subcontractor's work does not eliminate the Contractor's responsibilities for all the work as defined in Article 7L.16., "Contractor's Responsibility for Work."

The Owner may pursue actions against the Contractor, including withholding of estimates and suspending the work, for noncompliance with the subcontract requirements of this section upon receipt of written notice with sufficient details showing the subcontractor has complied with contractual obligations.

FINAL PAYMENT

When the Contract has been completed, all work has been approved, final acceptance has been made in accordance with Article 5L.12., "Final Acceptance," and Contractor submittals have been received, the Engineer will prepare a final estimate for payment showing the total quantity of work completed and the money owed the Contractor. The final payment will reflect the entire sum due, less any sums previously paid.

**C. SPECIAL PROVISIONS (FEDERAL-AID CONSTRUCTION
CONTRACTS)**

Special Provision to Item 000 Nondiscrimination



1. DESCRIPTION

All recipients of federal financial assistance are required to comply with various nondiscrimination laws including Title VI of the Civil Rights Act of 1964, as amended, (Title VI). Title VI forbids discrimination against anyone in the United States on the grounds of race, color, or national origin by any agency receiving federal funds.

Owner, as a recipient of Federal financial assistance, and under Title VI and related statutes, ensures that no person shall on the grounds of race, religion (where the primary objective of the financial assistance is to provide employment per 42 U.S.C. § 2000d-3), color, national origin, sex, age or disability be excluded from participation in, be denied the benefits of, or otherwise be subjected to discrimination under any of Owner's programs or activities.

2. DEFINITION OF TERMS

Where the term "contractor" appears in the following six nondiscrimination clauses, the term "contractor" is understood to include all parties to contracts or agreements with the Owner.

3. NONDISCRIMINATION PROVISIONS

During the performance of this contract, the contractor agrees as follows:

3.1. **Compliance with Regulations.** The Contractor shall comply with the Regulations relative to nondiscrimination in Federally-assisted programs of the Department of Transportation (hereinafter, "DOT") Title 49, Code of Federal Regulations, Part 21, as they may be amended from time to time, (hereinafter referred to as the Regulations), which are herein incorporated by reference and made a part of this contract.

3.2. **Nondiscrimination.** The contractor, with regard to the work performed by it during the contract, shall not discriminate on the grounds of race, color, or national origin in the selection and retention of subcontractors, including procurements of materials and leases of equipment. The contractor shall not participate either directly or indirectly in the discrimination prohibited by section 21.5 of the Regulations, including employment practices when the contract covers a program set forth in Appendix B of the Regulations.

3.3. **Solicitations for Subcontracts, Including Procurements of Materials and Equipment:** In all solicitations either by competitive bidding or negotiation made by the contractor for work to be performed under a subcontract, including procurements of materials or leases of equipment, each potential subcontractor or supplier shall be notified by the contractor of the contractor's obligations under this contract and the Regulations relative to nondiscrimination on the grounds of race, color, or national origin.

- 3.4. **Information and Reports:** The contractor shall provide all information and reports required by the Regulations or directives issued pursuant thereto, and shall permit access to its books, records, accounts, other sources of information, and its facilities as may be determined by the Owner or the Texas Department of Transportation to be pertinent to ascertain compliance with such Regulations, orders and instructions. Where any information required of a contractor is in the exclusive possession of another who fails or refuses to furnish this information the contractor shall so certify to the Owner or the Texas Department of Transportation as appropriate, and shall set forth what efforts it has made to obtain the information.
- 3.5. **Sanctions for Noncompliance.** In the event of the contractor's noncompliance with the nondiscrimination provisions of this contract, the Owner shall impose such contract sanctions as it, the Owner may determine to be appropriate, including, but not limited to:
- withholding of payments to the contractor under the contract until the contractor complies, and/or
 - cancellation, termination or suspension of the contract, in whole or in part.
- 3.6. **Incorporation of Provisions.** The contractor shall include the provisions of paragraphs (3.1) through (3.6) in every subcontract, including procurements of materials and leases of equipment, unless exempt by the Regulations, or directives issued pursuant thereto. The contractor shall take such action with respect to any subcontract or procurement as the Owner may direct as a means of enforcing such provisions including sanctions for non-compliance: provided, however that, in the event a contractor becomes involved in, or is threatened with, litigation with a subcontractor or supplier as a result of such direction, the contractor may request the Owner to enter into such litigation to protect the interests of the Owner, and, in addition, the contractor may request the United States to enter into such litigation to protect the interests of the United States.

Special Provision to Item 000

Certification of Nondiscrimination in Employment



1. GENERAL

By signing this proposal, the Bidder certifies that Bidder has participated in a previous contract or subcontract subject to the equal opportunity clause, as required by Executive Orders 10925, 11114, or 11246, or if Bidder has not participated in a previous contract of this type, or if Bidder has had previous contract or subcontracts and has not filed, Bidder will file with the Joint Reporting Committee, the Director of the Office of Federal Contract Compliance, a Federal Government contracting or administering agency, or the former President's Committee on Equal Employment Opportunity, all reports due under the applicable filing requirements.

Note—The above certification is required by the Equal Employment Opportunity Regulations of the Secretary of Labor (41 CFR 60-1.7(b)(1)), and must be submitted by Bidders and proposed subcontractors only in connection with contracts and subcontracts which are subject to the equal opportunity clause. Contracts and subcontracts which are exempt from the equal opportunity clause are set forth in 41 CFR 60-1.5. (Generally only contracts or subcontracts of \$10,000 or under are exempt.)

Currently, Standard Form 100 (EEO-1) is the only report required by the Executive Orders or their implementing regulations.

Proposed prime contractors and subcontractors who have participated in a previous contract or subcontract subject to the Executive Orders and have not filed the required reports should note that 41 CFR 60-1.7(b)(1) prevents the award of contracts and subcontracts unless such contractor submits a report covering the delinquent period or such other period specified by the Federal Highway Administration or by the Director, Office of Federal Contract Compliance, U.S. Department of Labor.

Special Provision to Item 000

Notice of Requirement for Affirmative Action to Ensure Equal Employment Opportunity (Executive Order 11246)



1. GENERAL

In addition to the affirmative action requirements of the Special Provision titled "Standard Federal Equal Employment Opportunity Construction Contract Specifications" as set forth elsewhere in this proposal, the Bidder's attention is directed to the specific requirements for utilization of minorities and females as set forth below.

2. GOALS

Goals for minority and female participation are hereby established in accordance with 41 CFR 60-4.

The goals for minority and female participation expressed in percentage terms for the Contractor's aggregate work force in each trade on all construction work in the covered area are as follows:

Goals for minority participation in each trade, %	Goals for female participation in each trade, %
See Table 1	6.9

These goals are applicable to all the Contractor's construction work (whether or not it is Federal or federally assisted) performed in the covered area. If the Contractor performs construction work in a geographical area located outside of the covered area, it will apply the goals established for such geographical area where the work is actually performed. With regard to this second area, the Contractor also is subject to the goals for both its federally involved and non-federally involved construction. The Contractor's compliance with the Executive Order and the regulations in 41 CFR Part 60-4 will be based on its implementation of the Standard Federal Equal Employment Opportunity Construction Contract Specifications Special Provision and its efforts to meet the goals. The hours of minority and female employment and training must be substantially uniform throughout the length of the Contract, and in each trade, and the Contractor must make a good faith effort to employ minorities and women evenly on each of its projects. The transfer of minority and female employees or trainees from Contractor to Contractor or from project to project for the sole purpose of meeting the Contractor's goals will be a violation of the Contract, the Executive Order and the regulations in 41 CFR Part 60-4. Compliance with the goals will be measured against the total work hours performed.

A Contractor or subcontractor will be considered in compliance with these provisions by participation in the Texas Highway-Heavy Branch, AGC, Statewide Training and Affirmative Action Plan. Provided that each Contractor or subcontractor participating in this plan must individually comply with the equal opportunity clause set forth in 41 CFR 60-1.4 and must make a good faith effort to achieve the goals set forth for each participating trade in the plan in which it has employees. The overall good performance of other Contractors and subcontractors toward a goal in an approved plan does not excuse any covered Contractor's or subcontractor's failure to make good faith efforts to achieve the goals contained in these provisions. Contractors or subcontractors participating in the plan must be able to demonstrate their participation and document their compliance with the provisions of this Plan.

3. SUBCONTRACTING

The Contractor must provide written notification to the Owner within 10 working days of award of any construction subcontract in excess of \$10,000 at any tier for construction work under the Contract resulting from this solicitation pending concurrence of the Owner in the award. The notification will list the names,

address and telephone number of the subcontractor; employer identification number; estimated dollar amount of the subcontract; estimated starting and completion dates of the subcontract; and the geographical area in which the Contract is to be performed.

4. COVERED AREA

As used in this special provision, and in the Contract resulting from this solicitation, the geographical area covered by these goals for female participation is the State of Texas. The geographical area covered by these goals for other minorities are the counties in the State of Texas as indicated in Table 1.

5. REPORTS

The Contractor is hereby notified that he may be subject to the Office of Federal Contract Compliance Programs (OFCCP) reporting and record keeping requirements as provided for under Executive Order 11246 as amended. OFCCP will provide direct notice to the Contractor as to the specific reporting requirements that he will be expected to fulfill.

Table 1
Goals for Minority Participation

County	Participation, %	County	Participation, %
Anderson	22.5	Chambers	27.4
Andrews	18.9	Cherokee	22.5
Angelina	22.5	Childress	11.0
Aransas	44.2	Clay	12.4
Archer	11.0	Cochran	19.5
Armstrong	11.0	Coke	20.0
Atascosa	49.4	Coleman	10.9
Austin	27.4	Collin	18.2
Bailey	19.5	Collingsworth	11.0
Bandera	49.4	Colorado	27.4
Bastrop	24.2	Comal	47.8
Baylor	11.0	Comanche	10.9
Bee	44.2	Concho	20.0
Bell	16.4	Cooke	17.2
Bexar	47.8	Coryell	16.4
Blanco	24.2	Cottle	11.0
Borden	19.5	Crane	18.9
Bosque	18.6	Crockett	20.0
Bowie	19.7	Crosby	19.5
Brazoria	27.3	Culberson	49.0
Brazos	23.7	Dallam	11.0
Brewster	49.0	Dallas	18.2
Briscoe	11.0	Dawson	19.5
Brooks	44.2	Deaf Smith	11.0
Brown	10.9	Delta	17.2
Burleson	27.4	Denton	18.2
Burnet	24.2	DeWitt	27.4
Caldwell	24.2	Dickens	19.5
Calhoun	27.4	Dimmit	49.4
Callahan	11.6	Donley	11.0
Cameron	71.0	Duval	44.2
Camp	20.2	Eastland	10.9
Carson	11.0	Ector	15.1
Cass	20.2	Edwards	49.4
Castro	11.0	Ellis	18.2

County	Participation, %	County	Participation, %
El Paso	57.8	Kenedy	44.2
Erath	17.2	Kent	10.9
Falls	18.6	Kerr	49.4
Fannin	17.2	Kimble	20.0
Fayette	27.4	King	19.5
Fisher	10.9	Kinney	49.4
Floyd	19.5	Kleberg	44.2
Foard	11.0	Knox	10.9
Fort Bend	27.3	Lamar	20.2
Franklin	17.2	Lamb	19.5
Freestone	18.6	Lampasas	18.6
Frio	49.4	LaSalle	49.4
Gaines	19.5	Lavaca	27.4
Galveston	28.9	Lee	24.2
Garza	19.5	Leon	27.4
Gillespie	49.4	Liberty	27.3
Glasscock	18.9	Limestone	18.6
Goliad	27.4	Lipscomb	11.0
Gonzales	49.4	Live Oak	44.2
Gray	11.0	Llano	24.2
Grayson	9.4	Loving	18.9
Gregg	22.8	Lubbock	19.6
Grimes	27.4	Lynn	19.5
Guadalupe	47.8	Madison	27.4
Hale	19.5	Marion	22.5
Hall	11.0	Martin	18.9
Hamilton	18.6	Mason	20.0
Hansford	11.0	Matagorda	27.4
Hardeman	11.0	Maverick	49.4
Hardin	22.6	McCulloch	20.0
Harris	27.3	McLennan	20.7
Harrison	22.8	McMullen	49.4
Hartley	11.0	Medina	49.4
Haskell	10.9	Menard	20.0
Hays	24.1	Midland	19.1
Hemphill	11.0	Milam	18.6
Henderson	22.5	Mills	18.6
Hidalgo	72.8	Mitchell	10.9
Hill	18.6	Montague	17.2
Hockley	19.5	Montgomery	27.3
Hood	18.2	Moore	11.0
Hopkins	17.2	Morris	20.2
Houston	22.5	Motley	19.5
Howard	18.9	Nacogdoches	22.5
Hudspeth	49.0	Navarro	17.2
Hunt	17.2	Newton	22.6
Hutchinson	11.0	Nolan	10.9
Irion	20.0	Nueces	41.7
Jack	17.2	Ochiltree	11.0
Jackson	27.4	Oldham	11.0
Jasper	22.6	Orange	22.6
Jeff Davis	49.0	Palo Pinto	17.2
Jefferson	22.6	Panola	22.5
Jim Hogg	49.4	Parker	18.2
Jim Wells	44.2	Parmer	11.0
Johnson	18.2	Pecos	18.9
Jones	11.6	Polk	27.4
Karnes	49.4	Potter	9.3
Kaufman	18.2	Presidio	49.0
Kendall	49.4	Randall	9.3

County	Participation, %	County	Participation, %
Rains	17.2	Reagan	20.0
Real	49.4	Throckmorton	10.9
Red River	20.2	Titus	20.2
Reeves	18.9	Tom Green	19.2
Refugio	44.2	Travis	24.1
Roberts	11.0	Trinity	27.4
Robertson	27.4	Tyler	22.6
Rockwall	18.2	Upshur	22.5
Runnels	20.0	Upton	18.9
Rusk	22.5	Uvalde	49.4
Sabine	22.6	Val Verde	49.4
San Augustine	22.5	Van Zandt	17.2
San Jacinto	27.4	Victoria	27.4
San Patricio	41.7	Walker	27.4
San Saba	20.0	Waller	27.3
Schleicher	20.0	Ward	18.9
Scurry	10.9	Washington	27.4
Shackelford	10.9	Webb	87.3
Shelby	22.5	Wharton	27.4
Sherman	11.0	Wheeler	11.0
Smith	23.5	Wichita	12.4
Somervell	17.2	Wilbarger	11.0
Starr	72.9	Willacy	72.9
Stephens	10.9	Williamson	24.1
Sterling	20.0	Wilson	49.4
Stonewall	10.9	Winkler	18.9
Sutton	20.0	Wise	18.2
Swisher	11.0	Wood	22.5
Tarrant	18.2	Yoakum	19.5
Taylor	11.6	Young	11.0
Terrell	20.0	Zapata	49.4
Terry	19.5	Zavala	49.4

Special Provision to Item 000

Standard Federal Equal Employment Opportunity

Construction Contract Specifications

(Executive Order 11246)



1. GENERAL

As used in these specifications:

- "Covered area" means the geographical area described in the solicitation from which this Contract resulted;
- "Director" means Director, Office of Federal Contract Compliance Programs, United States Department of Labor, or any person to whom the Director delegates authority;
- "Employer identification number" means the Federal Social Security number used on the Employer's Quarterly Federal Tax Return, U.S. Treasury Department Form 941.
- "Minority" includes:
 - Black (all persons having origins in any of the Black African racial groups not of Hispanic origin);
 - Hispanic (all persons of Mexican, Puerto Rican, Cuban, Central or South American or other Spanish Culture or origin, regardless of race);
 - Asian and Pacific Islander (all persons having origins in any of the original peoples of the Far East, Southeast Asia, the Indian Subcontinent, or the Pacific Islands); and
 - American Indian or Alaskan Native (all persons having origins in any of the original peoples of North American and maintaining identifiable tribal affiliations through membership and participation or community identification).

Whenever the Contractor, or any Subcontractor at any tier, subcontracts a portion of the work involving any construction trade, it will physically include in each subcontract in excess of \$10,000 the provisions of these specifications and the Notice which contains the applicable goals for minority and female participation and which is set forth in the solicitations from which this Contract resulted.

If the Contractor is participating (pursuant to 41 CFR 60-4.5) in a Hometown Plan approved by the U. S. Department of Labor in the covered area either individually or through an association, its affirmative action obligations on all work in the Plan area (including goals and timetables) will be in accordance with that plan for those trades which have unions participating in the Plan. Contractors must be able to demonstrate their participation in and compliance with the provisions of any such Hometown Plan. Each Contractor or Subcontractor participating in an approved Plan is individually required to comply with its obligations under the equal employment opportunity (EEO) clause, and to make a good faith effort to achieve each goal under the Plan in each trade in which it has employees. The overall good faith performance by other Contractors or Subcontractors toward a goal in an approved Plan does not excuse any covered Contractor's or Subcontractor's failure to take good faith efforts to achieve the Plan goals and timetables.

The Contractor will implement the specific affirmative action standards provided in Section 1.7.1. through Section 1.7.16. of these specifications. The goals set forth in the solicitation from which this Contract resulted are expressed as percentages of the total hours of employment and training of minority and female utilization the Contractor should reasonably be able to achieve in each construction trade in which it has employees in the covered area. Covered construction Contractors performing Contracts in geographical areas where they do not have a Federal or federally assisted construction Contract will apply the minority and female goals established for the geographical area where the Contract is being performed. Goals are published periodically in the Federal Register in notice form and such notices may be obtained from any Office of Federal Contract Compliance Programs office or any Federal procurement contracting officer. The

Contractor is expected to make substantially uniform progress toward its goals in each craft during the period specified.

Neither the provisions of any collective bargaining agreement, nor the failure by a union with whom the Contractor has a collective bargaining agreement, to refer either minorities or women will excuse the Contractor's obligations under these specifications, Executive Order 11246, or the regulations promulgated pursuant thereto.

In order for the nonworking training hours of apprentices and trainees to be counted in meeting the goals, such apprentices and trainees must be employed by the Contractor during the training period, and the Contractor must have made a commitment to employ the apprentices and trainees at the completion of their training, subject to the availability of employment opportunities. Trainees must be trained pursuant to training programs approved by the U. S. Department of Labor.

The Contractor will take specific affirmative actions to ensure equal employment opportunity. The evaluation of the Contractor's compliance with these specifications will be based upon its effort to achieve maximum results from its actions. The Contractor will document these efforts fully, and will implement affirmative action steps at least as extensive as the following:

- 2.1.1. Ensure and maintain a working environment free of harassment, intimidation, and coercion at all sites, and in all facilities at which the Contractor's employees are assigned to work. The Contractor, where possible, will assign two or more women to each construction project. The Contractor will specifically ensure that all foremen, superintendents, and other on-site supervisory personnel are aware of and carry out the Contractor's obligation to maintain such a working environment, with specific attention to minority or female individuals working at such sites or in such facilities.
- 2.1.2. Establish and maintain a current list of minority and female recruitment sources, provide written notification to minority and female recruitment sources and to community organizations when the Contractor or its unions have employment opportunities available, and maintain a record of the organizations' responses.
- 2.1.3. Maintain a current file of the names, addresses and telephone numbers of each minority and female off-the-street applicant and minority or female referral from a union, a recruitment source or community organization and of what action was taken with respect to each such individual. If such individual was sent to the union hiring hall for referral and was not referred back to the Contractor by the union or, if referred, not employed by the Contractor, this will be documented in the file with the reason therefor, along with whatever additional actions the Contractor may have taken.
- 2.1.4. Provide immediate written notification to the Director when the union or unions with which the Contractor has a collective bargaining agreement has not referred to the Contractor a minority person or woman sent by the Contractor, or when the Contractor has other information that the union referral Process has impeded the Contractor's efforts to meet its obligations.
- 2.1.5. Develop on-the-job training opportunities and/or participate in training programs for the area which expressly include minorities and women, including upgrading programs and apprenticeship and trainee programs relevant to the Contractor's employment needs, especially those programs funded or approved by the U.S. Department of Labor. The Contractor will provide notice of these programs to the sources compiled under 7b above.
- 2.1.6. Disseminate the Contractor's EEO policy by providing notice of the policy to unions and training programs and requesting their cooperation in assisting the Contractor in meeting its EEO obligations; by including it in any policy manual and Collective bargaining agreement; by publicizing it in the company newspaper, annual report, etc.; by specific review of the policy with all management personnel and with all minority and female employees at least once a year; and by posting the company EEO policy on bulletin boards accessible to all employees at each location where construction work is performed.
- 2.1.7. Review, at least annually, the company's EEO policy and affirmative action obligations under these specifications with all employees having any responsibility for hiring, assignment, layoff, termination or other

employment decisions including specific review of these items with on-site supervisory personnel such as Superintendents, General Foremen, etc., before the initiation of construction work at any job site. A written record must be made and maintained identifying the time and place of these meetings, persons attending, subject matter discussed, and disposition of the subject matter.

- 2.1.8. Disseminate the Contractor's EEO policy externally by including it in any advertising in the news media, specifically including minority and female news media, and providing written notification to and discussing the Contractor's EEO policy with other Contractors and Subcontractors with whom the Contractor does or anticipates doing business.
- 2.1.9. Direct its recruitment efforts, both oral and written, to minority, female and community organizations, to schools with minority and female students and to minority and female recruitment and training organizations serving the Contractor's recruitment area and employment needs. Not later than one month before the date for the acceptance of applications for apprenticeship or other training by any recruitment source, the Contractor will send written notification to organizations such as the above, describing the openings, screening procedures, and tests to be used in the selection process.
- 2.1.10. Encourage present minority and female employees to recruit other minority persons and women and, where reasonable, provide after school, summer and vacation employment to minority and female youth both on the site and in other areas of a Contractor's workforce.
- 2.1.11. Validate all tests and other selection requirements where there is an obligation to do so under 41 CFR Part 60-3.
- 2.1.12. Conduct, at least annually, an inventory and evaluation at least of all minority and female personnel for promotional opportunities and encourage these employees to seek or to prepare for, through appropriate training, etc., such opportunities.
- 2.1.13. Ensure that seniority practices, job classifications, work assignments and other personnel practices, do not have a discriminatory effect by continually monitoring all personnel and employment-related activities to ensure that the EEO policy and the Contractor's obligations under these specifications are being carried out.
- 2.1.14. Ensure that all facilities and company activities are non-segregated except that separate or single-user toilet and necessary changing facilities will be provided to assure privacy between the sexes.
- 2.1.15. Document and maintain a record of all solicitations of offers for subcontracts from minority and female construction contractors and suppliers, including circulation of solicitations to minority and female contractor associations and other business associations.
- 2.1.16. Conduct a review, at least annually, of all supervisors' adherence to and performance under the Contractor's EEO policies and affirmative action obligations.

Contractors are encouraged to participate in voluntary associations which assist in fulfilling one or more of their affirmative action obligations (Section 7.1. through Section 7.16.). The efforts of a contractor association, joint contractor-union, contractor-community, or other similar group of which the Contractor is a member and participant, may be asserted as fulfilling any one or more of its obligations under Section 7.1. through Section 7.16. of these Specifications provided that the Contractor actively participates in the group, makes every effort to assure that the group has a positive impact on the employment of minorities and women in the industry, ensures that the concrete benefits of the program are reflected in the Contractor's minority and female workforce participation, makes a good faith effort to meet its individual goals and timetables, and can provide access to documentation which demonstrates the effectiveness of actions taken on behalf of the Contractor. The obligation to comply, however, is the Contractor's and failure of such a group to fulfill an obligation will not be a defense for the Contractor's noncompliance.

A single goal for minorities and a separate single goal for women have been established. The Contractor, however, is required to provide equal employment opportunity and to take affirmative action for all minority groups, both male and female, and all women, both minority and non-minority. Consequently, the Contractor

may be in violation of the Executive Order if a particular group is employed in a substantially disparate manner (for example, even though the Contractor has achieved its goals for women generally, the Contractor may be in violation of the Executive Order if a specific minority group of women is underutilized).

The Contractor shall not use the goals and timetables or affirmative action standards to discriminate against any person because of race, color, religion, sex, or national origin.

The Contractor will not enter into any Subcontract with any person or firm debarred from Government Contracts pursuant to Executive Order 11246.

The Contractor will carry out such sanctions and penalties for violation of these specifications and of the Equal Opportunity Clause, including suspension, termination and cancellation of existing subcontracts as may be imposed or ordered pursuant to Executive Order 11246, as amended, and its implementing regulations, by the Office of Federal Contract Compliance Programs. Any Contractor who fails to carry out such sanctions and penalties will be in violation of these specifications and Executive Order 11246, as amended.

The Contractor, in fulfilling its obligations under these specifications, will implement specific affirmative action steps, at least as extensive as those standards prescribed in paragraph 7 of these specifications, so as to achieve maximum results from its efforts to ensure equal employment opportunity. If the Contractor fails to comply with the requirements of the Executive Order, the implementing regulations, or these specifications, the Director will proceed in accordance with 41 CFR 60-4.8.

The Contractor will designate a responsible official to monitor all employment-related activity to ensure that the company EEO policy is being carried out, to submit reports relating to the provisions hereof as may be required by the Government and to keep records. Records must at least include for each employee the name, address, telephone numbers, construction trade, union affiliation if any, employee identification number when assigned, social security number, race, sex, status (e.g., mechanic, apprentice, trainee, helper, or laborer), dates of changes in status, hours worked per week in the indicated trade, rate of pay, and locations at which the work was performed. Records must be maintained in an easily understandable and retrievable form; however, to the degree that existing records satisfy this requirement, Contractors shall not be required to maintain separate records.

Nothing herein provided will be construed as a limitation upon the application of other laws which establish different standards of compliance or upon the application of requirements for the hiring of local or other area residents (e.g., those under the Public Works Employment Act of 1977 and the Community Development Block Grant Program).

In addition to the reporting requirements set forth elsewhere in this Contract, the Contractor and the subcontractors holding subcontracts, not including material suppliers, of \$10,000 or more, will submit for every month of July during which work is performed, employment data as contained under Form PR 1391 (Appendix C to 23 CFR, Part 230), and in accordance with the included instructions.

Special Provision 000



Cargo Preference Act Requirements in Federal Aid Contracts

1. DESCRIPTION

All recipients of federal financial assistance are required to comply with the U.S. Department of Transportation's (DOT) Cargo Preference Act Requirements, 46 CFR Part 381, Use of United States-Flag Vessels.

This requirement applies to material or equipment that is acquired specifically for a Federal-aid highway project. It is not applicable to goods or materials that come into inventories independent of a Federal Highway Administration (FHWA) funded contract.

When oceanic shipments are necessary for materials or equipment acquired for a specific Federal-aid construction project, the contractor agrees to:

- Utilize privately owned United States-flag commercial vessels to ship at least 50 percent of the gross tonnage (computed separately for dry bulk carriers, dry cargo liners, and tankers) involved, whenever shipping any equipment, material, or commodities pursuant to this contract, to the extent such vessels are available at fair and reasonable rates for United States-flag commercial vessels.
- Furnish a legible copy of a rated, on-board commercial ocean bill-of-lading in English for each shipment of cargo described in paragraph (b) (1) of 46 CFR Part 381 Section 7, "Federal Grant, Guaranty, Loan and Advance of Funds Agreements," within 20 days following the date of loading for shipments originating within the United States or within 30 working days following the date of loading for shipments originating outside the United States, to both the Engineer (through the prime contractor in the case of subcontractor bills-of-lading) and to the Division of National Cargo, Office of Market Development, Maritime Administration, Washington, DC 20590.
- Insert the substance of the provisions of this clause in all subcontracts issued pursuant to this contract.

Special Provision to Item 000

Disadvantaged Business Enterprise in Federal-Aid Contracts



1. DESCRIPTION

The purpose of this Special Provision is to carry out the U.S. Department of Transportation's (DOT) policy of ensuring nondiscrimination in the award and administration of DOT-assisted Contracts and creating a level playing field on which firms owned and controlled by individuals who are determined to be socially and economically disadvantaged can compete fairly for DOT-assisted Contracts.

2. DISADVANTAGED BUSINESS ENTERPRISE IN FEDERAL-AID CONTRACTS

Policy. It is the policy of the DOT and the Texas Department of Transportation (Department) that DBEs, as defined in 49 CFR Part 26, Subpart A, and the Department's DBE Program, will have the opportunity to participate in the performance of Contracts financed in whole or in part with federal funds. The DBE requirements of 49 CFR Part 26, and the Department's DBE Program, apply to this Contract as follows.

The Contractor will solicit DBEs through reasonable and available means, as defined in 49 CFR Part 26, Appendix A, and the Department's DBE Program, or show a good faith effort to meet the DBE goal for this Contract.

The Contractor, subrecipient, or subcontractor will not discriminate on the basis of race, color, national origin, or sex in the performance of this Contract. Carry out applicable requirements of 49 CFR Part 26 in the award and administration of DOT-assisted Contracts. Failure to carry out these requirements is a material breach of this Contract, which may result in the termination of this Contract or such other remedy as the recipient deems appropriate.

The requirements of this Special Provision must be physically included in any subcontract.

By signing the Contract proposal, the Bidder is certifying that the DBE goal as stated in the proposal will be met by obtaining commitments from eligible DBEs or that the Bidder will provide acceptable evidence of good faith effort to meet the commitment.

Definitions.

- 2.1.1. **Administrative Reconsideration.** A process by which the low bidder may request reconsideration when the Department determines the good faith effort (GFE) requirements have not been met.
- 2.1.2. **Commercially Useful Function (CUF).** A CUF occurs when a DBE has the responsibility for the execution of the work and carrying out such responsibilities by actually performing, managing, and supervising the work.
- 2.1.3. **Disadvantaged Business Enterprise (DBE).** A for-profit small business certified through the Texas Unified Certification Program in accordance with 49 CFR Part 26, that is at least 51% owned by one or more socially and economically disadvantaged individuals, or in the case of a publicly owned business, in which is at least 51% of the stock is owned by one or more socially and economically disadvantaged individuals, and whose management and daily business operations are controlled by one or more of the individuals who own it.
- 2.1.4. **DBE Joint Venture.** An association of a DBE firm and one or more other firms to carry out a single business enterprise for profit for which purpose they combine their property, capital, efforts, skills, and knowledge, and

in which the DBE is responsible for a distinct, clearly defined portion of the work of the Contract and whose share in the capital contribution, control, management, risks, and profits of the joint venture are commensurate with its ownership interest.

- 2.1.5. **DOT.** The U.S. Department of Transportation, including the Office of the Secretary, the Federal Highway Administration (FHWA), the Federal Transit Administration (FTA), and the Federal Aviation Administration (FAA).
- 2.1.6. **Federal-Aid Contract.** Any Contract between the Owner and a Contractor that is paid for in whole or in part with DOT financial assistance.
- 2.1.7. **Good Faith Effort.** All necessary and reasonable steps to achieve the contract goal which, by their scope, intensity, and appropriateness to the objective, could reasonably be expected to obtain sufficient DBE participation, even if not fully successful. Good faith efforts are evaluated prior to award and throughout performance of the Contract. For guidance on good faith efforts, see 49 CFR Part 26, Appendix A.
- 2.1.8. **North American Industry Classification System (NAICS).** A designation that best describes the primary business of a firm. The NAICS is described in the North American Industry Classification Manual—United States, which is available on the Internet at the U.S. Census Bureau website:
<http://www.census.gov/eos/www/naics/>.
- 2.1.9. **Race-Conscious.** A measure or program that is focused specifically on assisting only DBEs, including women-owned businesses.
- 2.1.10. **Race-Neutral DBE Participation.** Any participation by a DBE through customary competitive procurement procedures.
- 2.1.11. **Texas Unified Certification Program (TUCP) Directory.** An online directory listing all DBEs currently certified by the TUCP. The Directory identifies DBE firms whose participation on a Contract may be counted toward achievement of the assigned DBE Contract goal.

Contractor's Responsibilities.

- 2.1.12. **DBE Liaison Officer.** Designate a DBE liaison officer who will administer the Contractor's DBE program and who will be responsible for maintenance of records of efforts and contacts made to subcontract with DBEs.
- 2.1.13. **Compliance Tracking System (CTS).** This Contract is subject to Contract compliance tracking. Contractors and DBEs are required to provide any noted and requested Contract compliance-related data to the Owner. This includes, but is not limited to, commitments, payments, substitutions, and good faith efforts. Contractors and DBEs are responsible for responding by any noted response date or due date to any instructions or request for information by the Owner.
- 2.1.14. **Apparent Low Bidder.** The apparent low bidder must submit DBE commitments to satisfy the DBE goal or submit good faith effort Form 2603 and supporting documentation demonstrating why the goal could not be achieved, in whole or part, no later than 5 calendar days after official bid results. The means of transmittal and the risk of timely receipt of the information will be the bidder's responsibility and no extension of the 5-calendar-day timeframe will be allowed for any reason.
- 2.1.15. **DBE Contractor.** A DBE Contractor may receive credit toward the DBE goal for work performed by its own forces and work subcontracted to DBEs. In the event a DBE subcontracts to a non-DBE, that information must be reported monthly.
- 2.1.16. **DBE Committal.** Only those DBEs certified by the TUCP are eligible to be used for goal attainment. The Directory can be accessed at the following Internet address:
<https://txdot.txdotcms.com/FrontEnd/VendorSearchPublic.asp?TN=txdot&XID=2340>.

A DBE must be certified on the day the commitment is considered and at time of subcontract execution. It is the Contractor's responsibility to ensure firms identified for participation are approved certified DBE firms.

The Bidder is responsible to ensure that all submittals are checked for accuracy. Any and all omissions, deletions, and/or errors that may affect the end result of the commitment package are the sole liabilities of the bidder.

Commitments in excess of the goal are considered race-neutral commitments.

- 2.1.17. **Good Faith Effort Requirements.** A Contractor who cannot meet the Contract goal, in whole or in part, must make adequate good faith efforts to obtain DBE participation as so stated and defined in 49 CFR Part 26, Appendix A.

- 2.1.17.1. **Administrative Reconsideration.** If the Owner determines that the apparent low bidder has failed to satisfy the good faith efforts requirement, the Owner will notify the Bidder of the failure and will give the Bidder an opportunity for administrative reconsideration.

The Bidder must request an administrative reconsideration of that determination within 3 days of the date of receipt of the notice. The request must be submitted directly to the Owner.

If a reconsideration request is timely received, the reconsideration decision will be made by the Owner's DBE liaison officer or, if the DBE liaison officer took part in the original determination that the Bidder failed to satisfy the good faith effort requirements, an Owner employee who holds a senior leadership position and reports directly to the executive officer, and who did not take part in the original determination will act as an administrative hearing officer. The Bidder may provide written documentation or argument concerning whether the assigned DBE contract goal was met or whether adequate good faith efforts were made to meet the Contract goal.

The DBE liaison or other Owner employee making the reconsideration determination may request a meeting with the Bidder to discuss whether the goal commitments were met or whether adequate good faith efforts were made to obtain the commitments to meet the Contract goal.

The meeting must be held within 7 days of the date of the request submitted under this section. If the Bidder is unavailable to meet during the 7-day period, the reconsideration decision will be made on the written information provided by the Bidder.

The Owner will provide to the Bidder a written decision that explains the basis for finding that the Bidder did not meet the Contract goal or did not make adequate good faith efforts to meet the Contract goal, within 7 days of the date of the notice issued in this section.

The reconsideration decision is final and not subject to administrative appeal.

- 2.1.18. **Determination of DBE Participation.** The work performed by the DBE must be reasonably construed to be included in the work area and NAICS work code identified by the Contractor in the approved commitment.

Participation by a DBE on a Contract will not be counted toward DBE goals until the amount of the participation has been paid to the DBE.

Payments made to a DBE that was not on the original commitment may be counted toward the Contract goal if that DBE was certified as a DBE before the execution of the subcontract and has performed a Commercially Useful Function.

The total amount paid to the DBE for work performed with its own forces is counted toward the DBE goal. When a DBE subcontracts part of the work of its Contract to another firm, the value of the subcontracted work may be counted toward DBE goals only if the subcontractor is itself a DBE.

DBE Goal credit for the DBE subcontractors leasing of equipment or purchasing of supplies from the Contractor or its affiliates is not allowed. Project materials or supplies acquired from an affiliate of the Contractor cannot directly or indirectly (second or lower tier subcontractor) be used for DBE goal credit.

If a DBE firm is declared ineligible due to DBE decertification after the execution of the DBE's subcontract, the DBE firm may complete the work and the DBE firm's participation will be counted toward the Contract goal. If the DBE firm is decertified before the DBE firm has signed a subcontract, the Contractor is obligated to replace the ineligible DBE firm or demonstrate that it has made good faith efforts to do so.

The Contractor may count 100% of its expenditure to a DBE manufacturer. According to 49 CFR 26.55(e)(1)(i), a DBE manufacturer is a firm that operates or maintains a factory or establishment that produces, on the premises, the materials, supplies, articles, or equipment required under the Contract and of the general character described by the specifications.

The Contractor may count only 60% of its expenditure to a DBE regular dealer. According to 49 CFR 26.55(e)(2)(i), a DBE regular dealer is a firm that owns, operates, or maintains a store, warehouse, or other establishment in which the materials, supplies, articles, or equipment of the general character described by the specifications and required under the Contract are bought, kept in stock, and regularly sold or leased to the public in the usual course of business. A firm may be a regular dealer in such bulk items as petroleum products, steel, cement, gravel, stone, or asphalt without owning, operating, or maintaining a place of business if the firm both owns and operates distribution equipment for the products. Any supplementing of regular dealers' own distribution equipment must be by a long-term lease agreement and not on an ad hoc or contract-by-contract basis. A long-term lease with a third-party transportation company is not eligible for 60% goal credit.

With respect to materials or supplies purchased from a DBE that is neither a manufacturer nor a regular dealer, the Contractor may count the entire amount of fees or commissions charged for assistance in the procurement of the materials and supplies, or fees or transportation charges for the delivery of materials or supplies required on a job site.

A Contractor may count toward its DBE goal a portion of the total value of the Contract amount paid to a DBE joint venture equal to the distinct, clearly defined portion of the work of the Contract performed by the DBE.

- 2.1.19. **Commercially Useful Function.** It is the Contractor's obligation to ensure that each DBE used on federal-assisted contracts performs a commercially useful function on the Contract.

The Owner will monitor performance during the Contract to ensure each DBE is performing a CUF.

Under the terms established in 49 CFR 26.55, a DBE performs a CUF when it is responsible for execution of the work of the Contract and is carrying out its responsibilities by actually performing, managing, and supervising the work involved.

With respect to material and supplies used on the Contract, a DBE must be responsible for negotiating price, determining quality and quantity, ordering the material, installing the material, if applicable, and paying for the material itself.

With respect to trucking, the DBE trucking firm must own and operate at least one fully licensed, insured, and operational truck used on the Contract. The DBE may lease trucks from another DBE firm, including an owner-operator who is certified as a DBE. The DBE who leases trucks from another DBE receives credit for the total value of the transportation services the lessee DBE provides on the Contract. The DBE may also lease trucks from a non-DBE firm, including from an owner-operator. The DBE that leases trucks equipped with drivers from a non-DBE is entitled to credit for the total value of transportation services provided by non-DBE leased trucks equipped with drivers not to exceed the value of transportation services on the Contract provided by DBE-owned trucks or leased trucks with DBE employee drivers. Additional participation by non-DBE owned trucks equipped with drivers receives credit only for the fee or commission it receives as a result of the lease arrangement.

A DBE does not perform a CUF when its role is limited to that of an extra participant in a transaction, Contract, or project through which funds are passed in order to obtain the appearance of DBE participation. The Owner will evaluate similar transactions involving non-DBEs in order to determine whether a DBE is an extra participant.

If a DBE does not perform or exercise responsibility for at least 30% of the total cost of its Contract with its own work force, or the DBE subcontracts a greater portion of the work than would be expected on the basis of normal industry practice for the type of work involved, the Owner will presume that the DBE is not performing a CUF.

If the Owner determines that a DBE is not performing a CUF, no work performed by such DBE will count as eligible participation. The denial period of time may occur before or after a determination has been made by the Owner.

In case of the denial of credit for non-performance, the Contractor will be required to provide a substitute DBE to meet the Contract goal or provide an adequate good faith effort when applicable.

- 2.1.19.1. **Rebuttal of a Finding of No Commercially Useful Function.** Consistent with the provisions of 49 CFR 26.55(c)(4)&(5), before the Owner makes a final finding that no CUF has been performed by a DBE, the Owner will notify the DBE and provide the DBE the opportunity to provide rebuttal information.

CUF determinations are not subject to administrative appeal.

- 2.1.20. **Joint Check.** The use of joint checks between a Contractor and a DBE is allowed with Owner approval. To obtain approval, the Contractor must submit a completed Form 2178, "DBE Joint Check Approval," to the Owner.

The Owner will closely monitor the use of joint checks to ensure that such a practice does not erode the independence of the DBE nor inhibit the DBE's ability to perform a CUF. When joint checks are utilized, DBE credit toward the Contract goal will be allowed only when the subcontractor is performing a CUF in accordance with 49 CFR 26.55(c)(1).

Long-term or open-ended joint checking arrangements may be a basis for further scrutiny and may result in the lack of participation towards the Contract goal requirement if DBE independence cannot be established.

Joint checks will not be allowed simply for the convenience of the Contractor.

If the proper procedures are not followed or the Owner determines that the arrangements result in a lack of independence for the DBE involved, no credit for the DBE's participation as it relates to the material cost will be used toward the Contract goal requirement, and the Contractor will need to make up the difference elsewhere on the project.

- 2.1.21. **DBE Termination and Substitution.** No DBE named in the commitment submitted under Section 2.3.5. will be terminated for convenience, in whole or part, without the Owner's approval. This includes, but is not limited to, instances in which a Contractor seeks to perform work originally designated for a DBE subcontractor with its own forces or those of an affiliate, a non-DBE firm, or with another DBE firm.

Unless consent is provided, the Contractor will not be entitled to any payment for work or material unless it is performed or supplied by the listed DBE.

The Contractor, prior to submitting its request to terminate, must first give written notice to the DBE of its intent to terminate and the reason for the termination. The Contractor will copy the Owner on the Notice of Intent to terminate.

The DBE has 5 calendar days to respond to the Contractor's notice and will advise the Contractor and the Owner of the reasons, if any, why it objects to the proposed termination of its subcontract and why the Owner should not approve the prime Contractor's request for termination.

The Owner may provide a shorter response time if required in a particular case as a matter of public necessity.

The Owner will consider both the Contractor's request and DBE's stated position prior to approving the request. The Owner may provide a written approval only if it agrees, for reasons stated in its concurrence document, that the Contractor has good cause to terminate the DBE. If the Owner does not approve the request, the Contractor must continue to use the committed DBE firm in accordance with the Contract. For guidance on what good cause includes, see 49 CFR 26.53.

Good cause does not exist if the Contractor seeks to terminate, reduce, or substitute a DBE it relied upon to obtain the Contract so that the Contractor can self-perform the work for which the DBE firm was engaged.

When a DBE subcontractor is terminated, make good faith efforts to find, as a substitute for the original DBE, another DBE to perform, at least to the extent needed to meet the established Contract goal, the work that the original DBE was to have performed under the Contract.

Submit the completed Form 2228, "DBE Termination Substitution Request," within seven (7) days, which may be extended for an additional 7 days if necessary at the request of the Contractor. The Owner will provide a written determination to the Contractor stating whether or not good faith efforts have been demonstrated.

- 2.1.22. **Reports and Records.** By the 15th of each month and after work begins, report payments to meet the DBE goal and for DBE race-neutral participation on projects with or without goals. These payment reports will be required until all DBE subcontracting or material supply activity is completed. Negative payment reports are required when no activity has occurred in a monthly period.

Notify the Owner if payment to any DBE subcontractor is withheld or reduced.

Before receiving final payment from the Owner, the Contractor must indicate a final payment on the compliance tracking system. The final payment is a summary of all payments made to the DBEs on the project.

All records must be retained for a period of 3 years following completion of the Contract work, and must be available at reasonable times and places for inspection by authorized representatives of the Owner, Texas Department of Transportation or the DOT. Provide copies of subcontracts or agreements and other documentation upon request.

- 2.1.23. **Failure to Comply.** If the Owner determines the Contractor has failed to demonstrate good faith efforts to meet the assigned goal, the Contractor will be given an opportunity for reconsideration by the Owner.

A Contractor's failure to comply with the requirements of this Special Provision will constitute a material breach of this Contract. In such a case, the Owner reserves the right to terminate the Contract; to deduct the amount of DBE goal not accomplished by DBEs from the money due or to become due the Contractor; or to secure a refund, not as a penalty but as liquidated damages, to the Owner or such other remedy or remedies as the Owner deems appropriate.

- 2.1.24. **Investigations.** The Owner may conduct reviews or investigations of participants as necessary. All participants, including, but not limited to, DBEs and complainants using DBE Subcontractors to meet the Contract goal, are required to cooperate fully and promptly with compliance reviews, investigations, and other requests for information.

2.1.25.

Falsification and Misrepresentation. If the Owner determines that a Contractor or subcontractor was a knowing and willing participant in any intended or actual subcontracting arrangement contrived to artificially inflate DBE participation or any other business arrangement determined by the Owner to be unallowable, or if the Contractor engages in repeated violations, falsification, or misrepresentation, the Owner may:

- refuse to count any fraudulent or misrepresented DBE participation;
- withhold progress payments to the Contractor commensurate with the violation;
- refer the matter to the Office of Inspector General of the US Department of Transportation for investigation; and/or
- seek any other available contractual remedy.

Special Provision to Item 000

Schedule of Liquidated Damages



The dollar amount of daily contract administration Liquidated Damages per Working Day is \$4,100.00.

Special Provision to Item 2L

Instructions to Bidders



1.

Item 2L, "Instructions to Bidders," of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Article 2L.3., "Issuing Bid Documents," second paragraph, is supplemented by the following.

The Owner will not issue a proposal form if one or more of the following apply:

- the Bidder or affiliate of the Bidder that was originally determined as the apparent low Bidder on a project but was deemed nonresponsive for failure to submit a DBE commitment as specified in Article 2L.13., "Disadvantaged Business Enterprise (DBE)," is prohibited from rebidding that specific project.

Article 2L.7., "Nonresponsive Bid," is supplemented by the following:

The Owner will not accept a nonresponsive bid. A bid that has one or more of the deficiencies listed below is considered nonresponsive:

- the Bidder failed to submit a DBE commitment as specified in Article 2L.13., "Disadvantaged Business Enterprise (DBE)."

Article 2L.13., "Disadvantaged Business Enterprise (DBE)," is added.

The apparent low bidder must submit DBE commitment information on federally funded projects with DBE goals within 5 calendar days (as defined in 49 CFR Part 26, Subpart A) after official bid results. For a submission that meets the 5-day requirement, administrative corrections will be allowed.

If the apparent low Bidder fails to submit their DBE information within the specified timeframe, the apparent low bidder will be deemed nonresponsive and the proposal guaranty will become the property of the Owner, not as a penalty, but as liquidated damages. The Bidder forfeiting the proposal guaranty will not be considered in future proposals for the same work unless there has been a substantial change in the design of the work. The Owner may recommend:

- reject all bids, or
- award the Contract to the new apparent low Bidder, if the new apparent low Bidder submits DBE information within one calendar day of notification by the Owner.

If the new apparent low Bidder is unable to submit the required DBE information within five calendar days:

- the new apparent low Bidder will not be deemed nonresponsive,
- the Bidder's guaranty will not be forfeited,
- the Owner will reject all bids, and
- the Bidder will remain eligible to receive future proposals for the same project.

Special Provision to Item 006 Control of Materials



Item 6, “Control of Materials” of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Section 1.1, “Buy America,” The section is removed and replaced by the following:

Comply with the latest provisions of Build America, Buy America Act (BABA Act) of the Bipartisan Infrastructure Law which restricts funds being made available from Federal financial assistance programs unless all the iron products, steel products, manufactured products, and construction materials used in the project are produced in the United States. Use steel or iron products, manufactured products, or construction materials produced in the United States except when:

- a waiver exists exempting the material from Buy America compliance,
- the cost of materials, including delivery, does not exceed 0.1% of the total Contract cost or \$2,500, whichever is greater,
- the Contract contains an alternate item for a foreign source product and the Contract is awarded based on the alternate item, or
- the materials are temporarily installed.

For construction materials submit a notarized original of TxDOT Construction Material Buy America Certification Form (Department Form 2806) with the proper attachments for verification of compliance. Form 2806 is not required for materials classified as manufactured products.

Construction Materials are classified as an article, material, or supply—other than an item of primarily iron or steel; a manufactured product; cement and cementitious materials; aggregates such as stone, sand, or gravel; or aggregate binding agents or additives—that is or consists primarily of:

- Non-ferrous metals,
- Plastic and polymer-based products (including polyvinylchloride, composite building materials, and polymers used in fiber optic cables),
- Glass (including optic glass)
- Lumber, or
- Drywall.

Details shown on the plans provide additional clarification on Buy America requirements for this project. Refer to the Buy America Material Classification Sheet for clarification on material categorization, located at: <https://www.txdot.gov/business/resources/materials/buy-america-material-classification-sheet.html>.

For steel or iron materials submit a notarized original of the FORM D-9-USA-1 (Department Form 1818) with the proper attachments for verification of compliance. For steel or iron materials the manufacturing process includes any process that modifies the chemical content, physical shape or size, or final finish of a product. The manufacturing process begins with initial melting and mixing and continues through fabrication (cutting, drilling, welding, bending, etc.) and coating (paint, galvanizing, epoxy, etc.).

Special Provision to Item 7L



Legal Relations and Responsibilities

Item 7L, "Legal Relations and Responsibilities," of the Standard Specifications is amended with respect to the clauses cited below.

Section 1.5.2., "Flaggers," the first paragraph is voided and replaced by the following:

- 1.5.2 **Flaggers.** Designate in writing, a flagger instructor who will serve as a flagging supervisor and is responsible for training and assuring that all flaggers are qualified to perform flagging duties. Certify to the Engineer that all flaggers will be trained and make available upon request a list of flaggers trained to perform flagging duties.

Section 1.5.5., "Training," is voided and replaced by the following:

- 1.5.5 **Training.** Train workers involved with the traffic control using Department-approved training as shown on the "Traffic Control Training" Material Producer List.

Coordinate enrollment, pay associated fees, and successfully complete Department-approved training or Contractor-developed training. Training is valid for the period prescribed by the provider. Except for law enforcement personnel training, refresher training is required every 4 yr. from the date of completion unless otherwise specified by the course provider. The Engineer may require training at a frequency instead of the period prescribed based on the Department's needs. Training and associated fees will not be measured or paid for directly but are considered subsidiary to pertinent Items.

Certify to the Engineer that workers involved in traffic control and other work zone personnel have been trained and make available upon request a copy of the certification of completion to the Engineer. Ensure the following is included in the certification of completion:

- name of provider and course title,
- name of participant,
- date of completion, and
- date of expiration.

Where Contractor-developed training or a Department-approved training course does not produce a certification, maintain a log of attendees. Make the log available upon request. Ensure the log is legible and includes the following:

- printed name and signature of participant,
- name and title of trainer, and
- date of training.

1.5.5.1. **Contractor-developed Training.** Develop and deliver Contractor-developed training meeting the minimum requirements established by the Department. The outline for this training must be submitted to the Engineer for approval at the preconstruction meeting. The CRP or designated alternate may deliver the training instead of the Department-approved training. The work performed and materials furnished to develop and deliver the training will not be measured or paid for directly but will be considered subsidiary to pertinent Items.

1.5.5.1.1. **Flagger Training Minimum Requirements.** A Contractor's certified flagging instructor is permitted to train other flaggers.

1.5.5.1.2. **Optional Contractor-developed Training for Other Work Zone Personnel.** For other work zone personnel, the Contractor may provide training meeting the curriculum shown below instead of Department-approved training.

Minimum curriculum for Contractor-provided training is as follows:

Contractor-developed training must provide information on the use of personnel protection equipment, occupational hazards and health risks, and other pertinent topics related to traffic management. The type and amount of training will depend on the job duties and responsibilities. Develop training applicable to the work being performed. Develop training to include the following topics.

- The Life You Save May Be Your Own (or other similar company safety motto).
- Purpose of the training.
 - It's the Law.
 - To make work zones safer for workers and motorists.
 - To understand what is needed for traffic control.
 - To save lives including your own.
- Personal and Co-Worker Safety.
 - **High Visibility Safety Apparel.** Discuss compliant requirements; inspect regularly for fading and reduced reflective properties; if night operations are required, discuss the additional and appropriate required apparel in addition to special night work risks; if moving operations are underway, discuss appropriate safety measures specific to the situation and traffic control plan.
 - **Blind Areas.** A blind area is the area around a vehicle or piece of construction equipment not visible to the operators, either by line of sight or indirectly by mirrors. Discuss the "Circle of Safety" around equipment and vehicles; use of spotters; maintain eye contact with equipment operators; and use of hand signals.
 - **Runovers and Backovers.** Remain alert at all times; keep a safe distance from traffic; avoid

turning your back to traffic and if you must then use a spotter; and stay behind protective barriers, whenever possible. Note: It is not safe to sit on or lean against a concrete barrier, these barriers can deflect four plus feet when struck by a vehicle.

- Look out for each other, warn co-workers.
- Be courteous to motorists.
- Do not run across active roadways.
- Workers must obey traffic laws and drive courteously while operating vehicles in the work zones.
- Workers must be made aware of company distracted driving policies.
- **Night Time Operations.** Focus should be placed on projects with a nighttime element.
- **Traffic Control Training.** Basics of Traffic Control.
 - Identify work zone traffic control supervisor and other appropriate persons to report issues to when they arise.
 - Emphasize that work zone traffic control devices must be in clean and in undamaged condition. If devices have been hit but not damaged, put back in their correct place and report to traffic control supervisor. If devices have been damaged, replace with new one and report to traffic control supervisor. If devices are dirty, faded or have missing or damaged reflective tape clean or replace and report to traffic control supervisor. Show examples of non-acceptable device conditions. Discuss various types of traffic control devices to be used and where spacing requirements can be found.
 - **Channelizing Devices and Barricades with Slanted Stripes.** Stripes are to slant in the direction you want traffic to stay or move to; demonstrate this with a device.
 - **Traffic Queuing.** Workers must be made aware of traffic queuing and the dangers created by it. Workers must be instructed to immediately notify the traffic control supervisor and other supervisory personnel if traffic is queuing beyond advance warning sign and devices or construction limits.
- **Signs.** Signs must be straight and not leaning. Report problems to the traffic control supervisor or other as designated for immediate repair. Covered signs must be fully covered. If covers are damaged or out of place, report to traffic control supervisor or other as designated.

Special Provision to Item 9L

Measurement and Payment



Item 9, "Measurement and Payment" of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Section 7.1.4.3., "Standby Equipment Costs," is voided and replaced by the following:

7.1.4.3. **Standby Equipment Costs.** Payment for standby equipment will be made in accordance with Section 9L.7.1.4., "Equipment," except that the 15% markup will not be allowed and that:

Section 7.1.4.3.1., "Contractor-Owned Equipment," is voided and replaced by the following:

7.1.4.3.1. **Contractor-Owned Equipment.** For Contractor-owned equipment:

- Standby will be paid at 50% of the monthly Equipment Watch rate after the regional and age adjustment factors have been applied. Operating costs will not be allowed. Calculate the standby rate as follows.

Standby rate = (FHWA hourly rate - operating costs) × 50%
- If an hourly rate is needed, divide the monthly *Equipment Watch* rate by 176.
- No more than 8 hr. of standby will be paid during a 24-hr. day period, nor more than 40 hr. per week.
- Standby costs will not be allowed during periods when the equipment would have otherwise been idle.

Special Provision to Item 506

Temporary Erosion, Sedimentation, and Environmental Controls



For this project, item 506, "Temporary Erosion, Sedimentation, and Environmental Controls," of the standard specifications, is hereby voided and replaced with the following.

1. DESCRIPTION

Install, maintain, and remove erosion, sedimentation, and environmental control measures to prevent or reduce the discharge of pollutants in accordance with the Storm Water Pollution Prevention Plan (SWP3) in the plans and the Texas Pollutant Discharge Elimination System (TPDES) General Permit TXR150000.

2. MATERIALS

Furnish materials in accordance with the following:

Item 161, "Compost"

Item 432, "Riprap"

Item 556, "Pipe Underdrains"

Rock Filter Dams.

- 2.1.1. **Aggregate.** Furnish aggregate with hardness, durability, cleanliness, and resistance to crumbling, flaking, and eroding acceptable to the Owner. Provide the following:
Types 1, 2, and 4 Rock Filter Dams. Use 3 to 6 in. aggregate.
Type 3 Rock Filter Dams. Use 4 to 8 in. aggregate.

- 2.1.2. **Wire.** Provide minimum 20 gauge galvanized wire for the steel wire mesh and tie wires for Types 2 and 3 rock filter dams. Type 4 dams require:
a double-twisted, hexagonal weave with a nominal mesh opening of 2-1/2 in. × 3-1/4 in.;
minimum 0.0866 in. steel wire for netting;
minimum 0.1063 in. steel wire for selvages and corners; and
minimum 0.0866 in. for binding or tie wire.

- 2.1.3. **Sandbag Material.** Furnish sandbags meeting Section 506.2.8., "Sandbags," except that any gradation of aggregate may be used to fill the sandbags.

Temporary Pipe Slope Drains. Provide corrugated metal pipe, polyvinyl chloride (PVC) pipe, flexible tubing, watertight connection bands, grommet materials, prefabricated fittings, and flared entrance sections that conform to the plans. Recycled and other materials meeting these requirements are allowed if approved.

Furnish concrete in accordance with Item 432, "Riprap."

Temporary Paved Flumes. Furnish asphalt concrete, hydraulic cement concrete, or other comparable non-erodible material that conforms to the plans. Provide rock or rubble with a minimum diameter of 6 in. and a maximum volume of 1/2 cu. ft. for the construction of energy dissipaters.

Construction Exits. Provide materials that meet the details shown on the plans and this Section.

- 2.1.4. **Rock Construction Exit.** Provide crushed aggregate for long- and short-term construction exits. Furnish aggregates that are clean, hard, durable, and free from adherent coatings such as salt, alkali, dirt, clay, loam, shale, soft or flaky materials, and organic and injurious matter. Use 4- to 8-in. aggregate for Type 1. Use 2- to 4-in. aggregate for Type 3.
- 2.1.5. **Timber Construction Exit.** Furnish No. 2 quality or better railroad ties and timbers for long-term construction exits, free of large and loose knots and treated to control rot. Fasten timbers with nuts and bolts or lag bolts, of at least 1/2 in. diameter, unless otherwise shown on the plans or allowed. Provide plywood or pressed wafer board at least 1/2 in. thick for short-term exits.
- 2.1.6. **Foundation Course.** Provide a foundation course consisting of flexible base, bituminous concrete, hydraulic cement concrete, or other materials as shown on the plans or directed.

Embankment for Erosion Control. Provide rock, loam, clay, topsoil, or other earth materials that will form a stable embankment to meet the intended use.

Pipe. Provide pipe outlet material in accordance with Item 556, "Pipe Underdrains," and details shown on the plans.

Construction Perimeter Fence.

- 2.1.7. **Posts.** Provide essentially straight wood or steel posts that are at least 60 in. long. Furnish soft wood posts with a minimum diameter of 3 in., or use nominal 2 × 4 in. boards. Furnish hardwood posts with a minimum cross-section of 1-1/2 × 1-1/5 in. Furnish T- or L-shaped steel posts with a minimum weight of 0.5 lb. per foot.
- 2.1.8. **Fence.** Provide orange construction fencing as approved.
- 2.1.9. **Fence Wire.** Provide 11 gauge or larger galvanized smooth or twisted wire. Provide 16 gauge or larger tie wire.
- 2.1.10. **Flagging.** Provide brightly-colored flagging that is fade-resistant and at least 3/4 in. wide to provide maximum visibility both day and night.
- 2.1.11. **Staples.** Provide staples with a crown at least 1/2 in. wide and legs at least 1/2 in. long.
- 2.1.12. **Used Materials.** Previously used materials meeting the applicable requirements may be used if approved.

Sandbags. Provide sandbag material of polypropylene, polyethylene, or polyamide woven fabric with a minimum unit weight of 4 oz. per square yard, a Mullen burst-strength exceeding 300 psi, and an ultraviolet stability exceeding 70%.

Use natural coarse sand or manufactured sand meeting the gradation given in Table 1 to fill sandbags. Filled sandbags must be 24 to 30 in. long, 16 to 18 in. wide, and 6 to 8 in. thick.

Table 1
Sand Gradation

Sieve #	Retained (% by Weight)
4	Maximum 3%
100	Minimum 80%
200	Minimum 95%

Aggregate may be used instead of sand for situations where sandbags are not adjacent to traffic. The aggregate size shall not exceed 3/8 in.

Temporary Sediment Control Fence. Provide a net-reinforced fence using woven geo-textile fabric. Logos visible to the traveling public will not be allowed.

- 2.1.13. **Fabric.** Provide fabric materials in accordance with DMS-6230, "Temporary Sediment Control Fence Fabric."
- 2.1.14. **Posts.** Provide essentially straight wood or steel posts with a minimum length of 48 in., unless otherwise shown on the plans. Furnish soft wood posts at least 3 in. in diameter, or use nominal 2 × 4 in. boards. Furnish hardwood posts with a minimum cross-section of 1-1/2 × 1-1/2 in. Furnish T- or L-shaped steel posts with a minimum weight of 1.3 lb. per foot.
- 2.1.15. **Net Reinforcement.** Provide net reinforcement of at least 12-1/2 gauge galvanized welded wire mesh, with a maximum opening size of 2 × 4 in., at least 24 in. wide, unless otherwise shown on the plans.
- 2.1.16. **Staples.** Provide staples with a crown at least 3/4 in. wide and legs 1/2 in. long.
- 2.1.17. **Used Materials.** Use recycled material meeting the applicable requirements if approved.

Biodegradable Erosion Control Logs.

- 2.1.18. **Core Material.** Furnish core material that is biodegradable or recyclable. Use compost, mulch, aspen excelsior wood fibers, chipped site vegetation, agricultural rice or wheat straw, coconut fiber, 100% recyclable fibers, or any other acceptable material unless specifically called out on the plans. Permit no more than 5% of the material to escape from the containment mesh. Furnish compost meeting the requirements of Item 161, "Compost."
- 2.1.19. **Containment Mesh.** Furnish containment mesh that is 100% biodegradable, photodegradable, or recyclable such as burlap, twine, UV photodegradable plastic, polyester, or any other acceptable material.
- Furnish biodegradable or photodegradable containment mesh when log will remain in place as part of a vegetative system.
- Furnish recyclable containment mesh for temporary installations.
- 2.1.20. **Size.** Furnish biodegradable erosion control logs with diameters shown on the plans or as directed. Stuff containment mesh densely so logs do not deform.

3. CONSTRUCTION

Contractor Responsibilities. Implement the Owner's Storm Water Pollution Prevention Plan (SWP3) for the project in accordance with the plans and specifications, TPDES General Permit TXR150000, and as directed by the Owner. Develop and implement an SWP3 for project-specific material supply plants within and outside of the Owner's right of way in accordance with the specific or general storm water permit requirements. Prevent water pollution from storm water associated with construction activity from entering any surface water or private property on or adjacent to the project site.

General.

- 2.1.1. **Phasing.** Implement control measures in the area to be disturbed before beginning construction, or as directed. Limit the disturbance to the area shown on the plans or as directed. If, in the opinion of the Owner, the Contractor cannot control soil erosion and sedimentation resulting from construction operations, the Owner will limit the disturbed area to that which the Contractor is able to control. Minimize disturbance to vegetation.
- 2.1.2. **Maintenance.** Immediately correct ineffective control measures. Implement additional controls as directed. Remove excavated material within the time requirements specified in the applicable storm water permit.
- 2.1.3. **Stabilization.** Stabilize disturbed areas where construction activities will be temporarily stopped in accordance with the applicable storm water permit. Establish a uniform vegetative cover. The project will not be accepted until a 70% density of existing adjacent undisturbed areas is obtained, unless otherwise shown on the plans. When shown on the plans, the Owner may accept the project when adequate controls are in

place that will control erosion, sedimentation, and water pollution until sufficient vegetative cover can be established.

- 2.1.4. **Finished Work.** Upon acceptance of vegetative cover, remove and dispose of all temporary control measures, temporary embankments, bridges, matting, falsework, piling, debris, or other obstructions placed during construction that are not a part of the finished work, or as directed.
- 2.1.5. **Restricted Activities and Required Precautions.** Do not discharge onto the ground or surface waters any pollutants such as chemicals, raw sewage, fuels, lubricants, coolants, hydraulic fluids, bitumens, or any other petroleum product. Operate and maintain equipment on-site to prevent actual or potential water pollution. Manage, control, and dispose of litter on-site such that no adverse impacts to water quality occur. Prevent dust from creating a potential or actual unsafe condition, public nuisance, or condition endangering the value, utility, or appearance of any property. Wash out concrete trucks only as described in the TPDES General Permit TXR150000. Utilize appropriate controls to minimize the offsite transport of suspended sediments and other pollutants if it is necessary to pump or channel standing water (i.e. dewatering). Prevent discharges that would contribute to a violation of Edwards Aquifer Rules, water quality standards, the impairment of a listed water body, or other state or federal law.

Installation, Maintenance, and Removal Work. Perform work in accordance with the SWP3, according to manufacturers' guidelines, and in accordance with the TPDES General Permit TXR150000. Install and maintain the integrity of temporary erosion and sedimentation control devices to accumulate silt and debris until soil disturbing activities are completed and permanent erosion control features are in place or the disturbed area has been adequately stabilized as determined by the Owner. . If a device ceases to function as intended, repair or replace the device or portions thereof as necessary. Remove sediment, debris, and litter. When approved, sediments may be disposed of within embankments, or in the right of way in areas where the material will not contribute to further siltation. Dispose of removed material in accordance with federal, state, and local regulations.

Remove devices upon approval or as directed. Finish-grade and dress the area upon removal. Stabilize disturbed areas in accordance with the permit, and as shown on the plans or directed. Materials removed are considered consumed by the project. Retain ownership of stockpiled material and remove it from the project when new installations or replacements are no longer required.

- 2.1.6. **Rock Filter Dams for Erosion Control.** Remove trees, brush, stumps, and other objectionable material that may interfere with the construction of rock filter dams. Place sandbags as a foundation when required or at the Contractor's option.

Place the aggregate to the lines, height, and slopes specified, without undue voids for Types 1, 2, 3, and 5. Place the aggregate on the mesh and then fold the mesh at the upstream side over the aggregate and secure it to itself on the downstream side with wire ties, or hog rings for Types 2 and 3, or as directed. Place rock filter dams perpendicular to the flow of the stream or channel unless otherwise directed. Construct filter dams according to the following criteria unless otherwise shown on the plans:

- 2.1.6.1. Type 1 (Non-reinforced).

Height. At least 18 in. measured vertically from existing ground to top of filter dam.

Top Width. At least 2 ft.

Slopes. No steeper than 2:1.

- 2.1.6.2. Type 2 (Reinforced).

Height. At least 18 in. measured vertically from existing ground to top of filter dam.

Top Width. At least 2 ft.

Slopes. No steeper than 2:1.

2.1.6.3. **Type 3 (Reinforced).**

Height. At least 36 in. measured vertically from existing ground to top of filter dam.

Top Width. At least 2 ft.

Slopes. No steeper than 2:1.

2.1.6.4. **Type 4 (Sack Gabions).** Unfold sack gabions and smooth out kinks and bends. Connect the sides by lacing in a single loop–double loop pattern on 4- to 5-in. spacing for vertical filling. Pull the end lacing rod at one end until tight, wrap around the end, and twist 4 times. Fill with stone at the filling end, pull the rod tight, cut the wire with approximately 6 in. remaining, and twist wires 4 times.

Place the sack flat in a filling trough, fill with stone, connect sides, and secure ends as described above for horizontal filling.

Lift and place without damaging the gabion. Shape sack gabions to existing contours.

2.1.6.5. **Type 5.** Provide rock filter dams as shown on the plans.

2.1.7. **Temporary Pipe Slope Drains.** Install pipe with a slope as shown on the plans or as directed. Construct embankment for the drainage system in 8-in. lifts to the required elevations. Hand-tamp the soil around and under the entrance section to the top of the embankment as shown on the plans or as directed. Form the top of the embankment or earth dike over the pipe slope drain at least 1 ft. higher than the top of the inlet pipe at all points. Secure the pipe with hold-downs or hold-down grommets spaced a maximum of 10 ft. on center. Construct the energy dissipaters or sediment traps as shown on the plans or as directed. Construct the sediment trap using concrete or rubble riprap in accordance with Item 432, "Riprap," when designated on the plans.

2.1.8. **Temporary Paved Flumes.** Construct paved flumes as shown on the plans or as directed. Provide excavation and embankment (including compaction of the subgrade) of material to the dimensions shown on the plans unless otherwise indicated. Install a rock or rubble riprap energy dissipater, constructed from the materials specified above, to a minimum depth of 9 in. at the flume outlet to the limits shown on the plans or as directed.

2.1.9. **Construction Exits.** Prevent traffic from crossing or exiting the construction site or moving directly onto a public roadway, alley, sidewalk, parking area, or other right of way areas other than at the location of construction exits when tracking conditions exist. Construct exits for either long- or short-term use.

2.1.9.1. **Long-Term.** Place the exit over a foundation course as required. Grade the foundation course or compacted subgrade to direct runoff from the construction exits to a sediment trap as shown on the plans or as directed. Construct exits with a width of at least 14 ft. for one-way and 20 ft. for two-way traffic for the full width of the exit, or as directed.

Type 1. Construct to a depth of at least 8 in. using crushed aggregate as shown on the plans or as directed.

Type 2. Construct using railroad ties and timbers as shown on the plans or as directed.

2.1.9.2. **Short-Term.**

Type 3. Construct using crushed aggregate, plywood, or wafer board. This type of exit may be used for daily operations where long-term exits are not practical.

Type 4. Construct as shown on the plans or as directed.

- 2.1.10. **Earthwork for Erosion Control.** Perform excavation and embankment operations to minimize erosion and to remove collected sediments from other erosion control devices.
- 2.1.10.1. **Excavation and Embankment for Erosion Control Features.** Place earth dikes, swales, or combinations of both along the low crown of daily lift placement, or as directed, to prevent runoff spillover. Place swales and dikes at other locations as shown on the plans or as directed to prevent runoff spillover or to divert runoff. Construct cuts with the low end blocked with undisturbed earth to prevent erosion of hillsides. Construct sediment traps at drainage structures in conjunction with other erosion control measures as shown on the plans or as directed.
- Create a sediment basin, where required, providing 3,600 cu. ft. of storage per acre drained, or equivalent control measures for drainage locations that serve an area with 10 or more disturbed acres at one time, not including offsite areas.
- 2.1.10.2. **Excavation of Sediment and Debris.** Remove sediment and debris when accumulation affects the performance of the devices, after a rain, and when directed.
- 2.1.11. **Construction Perimeter Fence.** Construct, align, and locate fencing as shown on the plans or as directed.
- 2.1.11.1. **Installation of Posts.** Embed posts 18 in. deep or adequately anchor in rock, with a spacing of 8 to 10 ft.
- 2.1.11.2. **Wire Attachment.** Attach the top wire to the posts at least 3 ft. from the ground. Attach the lower wire midway between the ground and the top wire.
- 2.1.11.3. **Flag Attachment.** Attach flagging to both wire strands midway between each post. Use flagging at least 18 in. long. Tie flagging to the wire using a square knot.
- 2.1.12. **Sandbags for Erosion Control.** Construct a berm or dam of sandbags that will intercept sediment-laden storm water runoff from disturbed areas, create a retention pond, detain sediment, and release water in sheet flow. Fill each bag with sand so that at least the top 6 in. of the bag is unfilled to allow for proper tying of the open end. Place the sandbags with their tied ends in the same direction. Offset subsequent rows of sandbags 1/2 the length of the preceding row. Place a single layer of sandbags downstream as a secondary debris trap. Place additional sandbags as necessary or as directed for supplementary support to berms or dams of sandbags or earth.
- 2.1.13. **Temporary Sediment-Control Fence.** Provide temporary sediment-control fence near the downstream perimeter of a disturbed area to intercept sediment from sheet flow. Incorporate the fence into erosion-control measures used to control sediment in areas of higher flow. Install the fence as shown on the plans, as specified in this Section, or as directed.
- 2.1.13.1. **Installation of Posts.** Embed posts at least 18 in. deep, or adequately anchor, if in rock, with a spacing of 6 to 8 ft. and install on a slight angle toward the runoff source.
- 2.1.13.2. **Fabric Anchoring.** Dig trenches along the uphill side of the fence to anchor 6 to 8 in. of fabric. Provide a minimum trench cross-section of 6 × 6 in. Place the fabric against the side of the trench and align approximately 2 in. of fabric along the bottom in the upstream direction. Backfill the trench, then hand-tamp.
- 2.1.13.3. **Fabric and Net Reinforcement Attachment.** Attach the reinforcement to wooden posts with staples, or to steel posts with T-clips, in at least 4 places equally spaced unless otherwise shown on the plans. Sewn vertical pockets may be used to attach reinforcement to end posts. Fasten the fabric to the top strand of reinforcement by hog rings or cord every 15 in. or less.
- 2.1.13.4. **Fabric and Net Splices.** Locate splices at a fence post with a minimum lap of 6 in. attached in at least 6 places equally spaced unless otherwise shown on the plans. Do not locate splices in concentrated flow areas.

Requirements for installation of used temporary sediment-control fence include the following:
 fabric with minimal or no visible signs of biodegradation (weak fibers),
 fabric without excessive patching (more than 1 patch every 15 to 20 ft.),
 posts without bends, and
 backing without holes.

- 2.1.14. **Biodegradable Erosion Control Logs.** Install biodegradable erosion control logs near the downstream perimeter of a disturbed area to intercept sediment from sheet flow. Incorporate the biodegradable erosion control logs into the erosion measures used to control sediment in areas of higher flow. Install, align, and locate the biodegradable erosion control logs as specified below, as shown in plans or as directed.
- Secure biodegradable erosion control logs in a method adequate to prevent displacement as a result of normal rain events, prevent damage to the logs, and to the satisfaction of the Owner such that flow is not allowed under the logs. Temporarily removing and replacing biodegradable erosion logs as to facilitate daily work is allowed at the Contractor's expense.
- 2.1.15. **Vertical Tracking.** Perform vertical tracking on slopes to temporarily stabilize soil. Provide equipment with a track undercarriage capable of producing a linear soil impression measuring a minimum of 12 in. long × 2 to 4 in. wide × 1/2 to 2 in. deep. Do not exceed 12 in. between track impressions. Install continuous linear track impressions where the 12 in. length impressions are perpendicular to the slope. Vertical tracking is required on projects where soil disturbing activities have occurred unless otherwise approved.

4. MEASUREMENT

Rock Filter Dams. Installation or removal of rock filter dams will be measured by the foot or by the cubic yard. The measured volume will include sandbags, when used.

- 2.1.1. **Linear Measurement.** When rock filter dams are measured by the foot, measurement will be along the centerline of the top of the dam.
- 2.1.2. **Volume Measurement.** When rock filter dams are measured by the cubic yard, measurement will be based on the volume of rock computed by the method of average end areas.
- 2.1.2.1. **Installation.** Measurement will be made in final position.
- 2.1.2.2. **Removal.** Measurement will be made at the point of removal.

Temporary Pipe Slope Drains. Temporary pipe slope drains will be measured by the foot.

Temporary Paved Flumes. Temporary paved flumes will be measured by the square yard of surface area. The measured area will include the energy dissipater at the flume outlet.

Construction Exits. Construction exits will be measured by the square yard of surface area.

Earthwork for Erosion and Sediment Control.

- 2.1.3. **Equipment and Labor Measurement.** Equipment and labor used will be measured by the actual number of hours the equipment is operated and the labor is engaged in the work.
- 2.1.4. **Volume Measurement.**
- 2.1.4.1. **In Place.**

Excavation. Excavation will be measured by the cubic yard in its original position and the volume computed by the method of average end areas.

Embankment. Embankment will be measured by the cubic yard in its final position by the method of average end areas. The volume of embankment will be determined between:

the original ground surfaces or the surface upon that the embankment is to be constructed for the feature and
the lines, grades and slopes of the accepted embankment for the feature.

2.1.4.2. **In Vehicles.** Excavation and embankment quantities will be combined and paid for under "Earthwork (Erosion and Sediment Control, In Vehicle)." Excavation will be measured by the cubic yard in vehicles at the point of removal. Embankment will be measured by the cubic yard in vehicles measured at the point of delivery. Shrinkage or swelling factors will not be considered in determining the calculated quantities.

Construction Perimeter Fence. Construction perimeter fence will be measured by the foot.

Sandbags for Erosion Control. Sandbags will be measured as each sandbag or by the foot along the top of sandbag berms or dams.

Temporary Sediment-Control Fence. Installation or removal of temporary sediment-control fence will be measured by the foot.

Biodegradable Erosion Control Logs. Installation or removal of biodegradable erosion control logs will be measured by the foot along the centerline of the top of the control logs.

Vertical Tracking. Vertical tracking will not be measured or paid for directly but is considered subsidiary to this Item.

5. PAYMENT

The following will not be paid for directly but are subsidiary to pertinent Items:

erosion-control measures for Contractor project-specific locations (PSLs) inside and outside the right of way (such as construction and haul roads, field offices, equipment and supply areas, plants, and material sources);

removal of litter, unless a separate pay item is shown on the plans;

repair to devices and features damaged by Contractor operations;

added measures and maintenance needed due to negligence, carelessness, lack of maintenance, and failure to install permanent controls;

removal and reinstallation of devices and features needed for the convenience of the Contractor;

finish grading and dressing upon removal of the device; and

minor adjustments including but not limited to plumbing posts, reattaching fabric, minor grading to maintain slopes on an erosion embankment feature, or moving small numbers of sandbags.

Stabilization of disturbed areas will be paid for under pertinent Items.

Furnishing and installing pipe for outfalls associated with sediment traps and ponds will not be paid for directly but is subsidiary to the excavation and embankment under this Item.

Rock Filter Dams. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid as follows:

2.1.1. **Installation.** Installation will be paid for as "Rock Filter Dams (Install)" of the type specified. This price is full compensation for furnishing and operating equipment, finish backfill and grading, lacing, proper disposal, labor, materials, tools, and incidentals.

2.1.2. **Removal.** Removal will be paid for as "Rock Filter Dams (Remove)." This price is full compensation for furnishing and operating equipment, proper disposal, labor, materials, tools, and incidentals.

When the Owner directs that the rock filter dam installation or portions thereof be replaced, payment will be made at the unit price bid for "Rock Filter Dams (Remove)" and for "Rock Filter Dams (Install)" of the type specified. This price is full compensation for furnishing and operating equipment, finish backfill and grading, lacing, proper disposal, labor, materials, tools, and incidentals.

Temporary Pipe Slope Drains. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Temporary Pipe Slope Drains" of the size specified. This price is full compensation for furnishing materials, removal and disposal, furnishing and operating equipment, labor, tools, and incidentals.

Removal of temporary pipe slope drains will not be paid for directly but is subsidiary to the installation Item. When the Owner directs that the pipe slope drain installation or portions thereof be replaced, payment will be made at the unit price bid for "Temporary Pipe Slope Drains" of the size specified, which is full compensation for the removal and reinstallation of the pipe drain.

Earthwork required for the pipe slope drain installation, including construction of the sediment trap, will be measured and paid for under "Earthwork for Erosion and Sediment Control."

Riprap concrete or stone, when used as an energy dissipater or as a stabilized sediment trap, will be measured and paid for in accordance with Item 432, "Riprap."

Temporary Paved Flumes. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Temporary Paved Flume (Install)" or "Temporary Paved Flume (Remove)." This price is full compensation for furnishing and placing materials, removal and disposal, equipment, labor, tools, and incidentals.

When the Owner directs that the paved flume installation or portions thereof be replaced, payment will be made at the unit prices bid for "Temporary Paved Flume (Remove)" and "Temporary Paved Flume (Install)." These prices are full compensation for the removal and replacement of the paved flume and for equipment, labor, tools, and incidentals.

Earthwork required for the paved flume installation, including construction of a sediment trap, will be measured and paid for under "Earthwork for Erosion and Sediment Control."

Construction Exits. Contractor-required construction exits from off right of way locations or on-right of way PSLs will not be paid for directly but are subsidiary to pertinent Items.

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" for construction exits needed on right of way access to work areas required by the Owner will be paid for at the unit price bid for "Construction Exits (Install)" of the type specified or "Construction Exits (Remove)." This price is full compensation for furnishing and placing materials, excavating, removal and disposal, cleaning vehicles, labor, tools, and incidentals.

When the Owner directs that a construction exit or portion thereof be removed and replaced, payment will be made at the unit prices bid for "Construction Exit (Remove)" and "Construction Exit (Install)" of the type specified. These prices are full compensation for the removal and replacement of the construction exit and for equipment, labor, tools, and incidentals.

Construction of sediment traps used in conjunction with the construction exit will be measured and paid for under "Earthwork for Erosion and Sediment Control."

Earthwork for Erosion and Sediment Control.

2.1.3. **Initial Earthwork for Erosion and Sediment Control.** The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Excavation (Erosion and Sediment Control, In Place)," "Embankment (Erosion and Sediment Control,

In Place), "Excavation (Erosion and Sediment Control, In Vehicle)," "Embankment (Erosion and Sediment Control, (In Vehicle)," or "Earthwork (Erosion and Sediment Control, In Vehicle)."

This price is full compensation for excavation and embankment including hauling, disposal of material not used elsewhere on the project; embankments including furnishing material from approved sources and construction of erosion-control features; and equipment, labor, tools, and incidentals.

Sprinkling and rolling required by this Item will not be paid for directly, but will be subsidiary to this Item.

- 2.1.4. **Maintenance Earthwork for Erosion and Sediment Control for Cleaning and Restoring Control Measures.** The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid under a Contractor Force Account Item from invoice provided to the Owner.

This price is full compensation for excavation, embankment, and re-grading including removal of accumulated sediment in various erosion control installations as directed, hauling, and disposal of material not used elsewhere on the project; excavation for construction of erosion-control features; embankments including furnishing material from approved sources and construction of erosion-control features; and equipment, labor, tools, and incidentals.

Earthwork needed to remove and obliterate erosion-control features will not be paid for directly but is subsidiary to pertinent Items unless otherwise shown on the plans.

Sprinkling and rolling required by this Item will not be paid for directly, but will be subsidiary to this Item.

Construction Perimeter Fence. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Construction Perimeter Fence." This price is full compensation for furnishing and placing the fence; digging, fence posts, wire, and flagging; removal and disposal; and materials, equipment, labor, tools, and incidentals.

Removal of construction perimeter fence will not be paid for directly but is subsidiary to the installation Item. When the Owner directs that the perimeter fence installation or portions thereof be removed and replaced, payment will be made at the unit price bid for "Construction Perimeter Fence," which is full compensation for the removal and reinstallation of the construction perimeter fence.

Sandbags for Erosion Control. Sandbags will be paid for at the unit price bid for "Sandbags for Erosion Control" (of the height specified when measurement is by the foot). This price is full compensation for materials, placing sandbags, removal and disposal, equipment, labor, tools, and incidentals.

Removal of sandbags will not be paid for directly but is subsidiary to the installation Item. When the Owner directs that the sandbag installation or portions thereof be replaced, payment will be made at the unit price bid for "Sandbags for Erosion Control," which is full compensation for the reinstallation of the sandbags.

Temporary Sediment-Control Fence. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid as follows:

- 2.1.5. **Installation.** Installation will be paid for as "Temporary Sediment-Control Fence (Install)." This price is full compensation for furnishing and operating equipment finish backfill and grading, lacing, proper disposal, labor, materials, tools, and incidentals.
- 2.1.6. **Removal.** Removal will be paid for as "Temporary Sediment-Control Fence (Remove)." This price is full compensation for furnishing and operating equipment, proper disposal, labor, materials, tools, and incidentals.

Biodegradable Erosion Control Logs. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid as follows:

- 2.1.7. **Installation.** Installation will be paid for as "Biodegradable Erosion Control Logs (Install)" of the size specified. This price is full compensation for furnishing and operating equipment finish backfill and grading, staking, proper disposal, labor, materials, tools, and incidentals.
- 2.1.8. **Removal.** Removal will be paid for as "Biodegradable Erosion Control Logs (Remove)." This price is full compensation for furnishing and operating equipment, proper disposal, labor, materials, tools, and incidentals.

Vertical Tracking. Vertical tracking will not be measured or paid for directly but is considered subsidiary to this Item.

D. SPECIAL PROVISIONS (TXDOT ITEMS)

Special Provision to Item 132 Embankment



Item 132, "Embankment" of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Article 132.3.4., "Compaction Methods." The last sentence is replaced by the following.

Compact embankments in accordance with Section 132.3.4.1., "Ordinary Compaction," or Section 132.3.4.2., "Density Control," as shown on the plans. The Contractor may use Section 132.3.4.3., "Density Control by Computer-Generated (CG) Curve," as an option for density control.

Article 132.3.4., "Compaction Methods," is supplemented by the following.

3.4.3. Density Control by Computer-Generated (CG) Curve. At the Contractor's discretion, CG curves may be used for density control.

Compact each layer to the required density using equipment complying with Item 210, "Rolling." Determine the maximum lift thickness based on the ability of the compacting operation and equipment to meet the required density. Do not exceed layer thickness of 12 in. loose or 10 in. compacted material, unless otherwise approved. Maintain a level layer with consistent thickness to ensure uniform compaction.

When using this method for each source and type of material, or when directed, sample and conduct testing according to the input parameters specified in Table 3 and provide CG field moisture-density curves based on each soil-compactor-lift thickness combination and CG Tex-114-E moisture-density curves based on each lift of soil. The CG field dry density (D_{fcg}) must be greater than or equal to the CG Tex-114-E maximum dry density (D_{acg}). The Engineer may obtain independent soil samples for supplemental Tex-114-E lab tests to check a supplemental maximum dry density (D_a) and optimum moisture content (W_{opt}) for reference when new CG curves are submitted. Provide access to the computer program used to generate the curve, when directed.

Table 3

**Computer-Generated Lab and Field Compaction Curve
Input Criteria**

Input Variables	Test Method
Liquid Limit, %	Tex-104-E
Plasticity Index (PI), %	Tex-106-E
Soil gradation	Tex-110-E Tex-111-E
Soil classification	Tex-112-E
Compaction roller brand, type, and model	N/A
Loose lift thickness, in.	N/A
Soil specific gravity	Use 2.65 for soil type SC. Use 2.68 for soil type CL. Use 2.69 for soil type CH.

Provide a compaction control report showing all input and output parameters and CG compaction curves, including:

- CG Tex-114-E laboratory maximum dry density (D_{acg}),
- CG Tex-114-E laboratory optimum moisture content (W_{optcg}),
- CG field maximum dry density (D_{fcg}),
- CG field optimum moisture content (W_{optcg}),
- graph of CG laboratory and field compaction curves and the “Zero Air Voids Line,” and
- minimum number of roller passes to achieve the required density and moisture content.

Meet the requirements for field maximum dry density (D_{fcg}) and field optimum moisture content (W_{optcg}) specified in Table 4, unless otherwise shown on the plans. Use only the specific roller and soil properties utilized in lift construction as input parameters to generate the CG field curve used to meet moisture-density requirements in construction.

Table 4

**Computer-Generated Lab and Field Compaction Curve
Input Criteria**

Description	Density	Moisture Content
	Tex-115-E	
PI ≤ 15	≥ 98% D _{fcg}	W _{optcg}
15 < PI ≤ 35	≥ 98% D _{fcg} and ≤ 102% D _{fcg}	W _{optcg}
PI > 35	≥ 95% D _{acg} and ≤ 100% D _{acg}	W _{optcg}

Each layer is subject to testing by the Engineer for density and moisture content. During compaction, the moisture content of the soil should be above CG optimum moisture content but should not exceed the value shown on the moisture-density curve, above optimum, required to achieve 98% dry density.

When the CG field maximum dry density (D_{fcg}) is not achieved, perform the following steps in order.

- Verify that construction controls including lift soil properties, minimum number and uniformity of compactor passes, lift thickness, and moisture content are correct.
- If needed, rework the lift with the corrected controls using the original CG curve.
- Generate a new CG field compaction curve based on actual in-place soil properties and rework the lift.
- Generate a non-CG Tex-114-E moisture-density reference standard and rework the material using this reference standard.

When required, remove small areas of the layer to allow for density tests. Replace the removed material and recompact at no additional expense to the Department. Proof-roll in accordance with Item 216, "Proof

Rolling," when shown on the plans or as directed. Correct soft spots as directed.

Article 132.3.5., "Maintenance of Moisture and Reworking." The first sentence is replaced by the following.

Maintain the density and moisture content once all requirements in Table 2 or 4 are met

Each layer is subject to testing by the Engineer for density and moisture content. During compaction, the moisture content of the soil should be above CG optimum moisture content but should not exceed the value shown on the moisture-density curve, above optimum, required to achieve 98% dry density.

When the CG field maximum dry density (D_{fcg}) is not achieved, perform the following steps in order.

- Verify that construction controls including lift soil properties, minimum number and uniformity of compactor passes, lift thickness, and moisture content are correct.
- If needed, rework the lift with the corrected controls using the original CG curve.
- Generate a new CG field compaction curve based on actual in-place soil properties and rework the lift.
- Generate a non-CG Tex-114-E moisture-density reference standard and rework the material using this reference standard.

When required, remove small areas of the layer to allow for density tests. Replace the removed material and recompact at no additional expense to the Department. Proof-roll in accordance with Item 216, "Proof

Rolling," when shown on the plans or as directed. Correct soft spots as directed.

Article 132.3.5., "Maintenance of Moisture and Reworking." The first sentence is replaced by the following.

Maintain the density and moisture content once all requirements in Table 2 or 4 are met

Special Provision to Item 247

Flexible Base



Item 247, "Flexible Base" of the Standard Specifications, is hereby amended with respect to the clauses cited below, and no other clauses or requirements of this Item are waived or changed hereby.

Section 2.4., "Certification." This section is added.

Personnel certified by the Department-approved soils and base certification program must conduct all sampling, field testing, and laboratory testing required by the following:

- Section 2.1, "Aggregate,"
- Section 2.1.3.2, "Recycled Material (Including Crushed Concrete) Requirements,"
- Section 4.3, "Compaction," for measuring flexible base depth, and
- Section 4.3.2, "Density Control," for determining the roadway density and moisture content.

Supply the Engineer with a list of certified personnel and copies of their current certificates before laboratory and field testing is performed and when personnel changes are made. At any time during the project, the Engineer may perform production tests as deemed necessary in accordance with Item 5, "Control of the Work."

Section 2.5., "Reporting and Responsibilities." This section is added.

Use Department-provided templates to record and calculate all test data. Obtain the current version of the templates at <http://www.txdot.gov/inside-txdot/forms-publications/consultants-contractors/forms/site-manager.html> or from the Engineer. The Engineer and the Contractor will provide any available test results to the other party when requested. Record and electronically submit all test results and pertinent information on Department-provided templates.

Section 2.6., "Sampling." This section is added.

The Engineer will sample flexible base from stockpiles located at the production site or at the project location in accordance with [Tex-400-A](#), Section 5.3. The Engineer will label the sample containers as "Engineer," "Contractor" or "Supplier," and "CST/M&P." Witness the sampling and take immediate possession of the sample containers labeled "Contractor" or "Supplier." The Engineer will maintain custody of the samples labeled "CST/M&P" until testing and reporting is completed.

Section 2.7., "Referee Testing." This section is added.

CST/M&P is the referee laboratory. The Contractor may request referee testing when the Engineer's test results fail to meet any of the material requirements listed in Table 1. Make the request via email within 5 working days after receiving test results from the Engineer. Submit test reports signed and sealed by a licensed professional engineer from a commercial laboratory listed on the Department's Material Producer List (MPL) of laboratories approved to perform compaction and triaxial compression testing located at <http://ftp.dot.state.tx.us/pub/txdot-info/cmd/mpl/complabs.pdf>. Submit completed test reports electronically on Department-provided templates in their original format. The referee laboratory will report test results to the Engineer within the allowable number of working days listed in Table 2 from the time the referee laboratory receives the samples. It is at the discretion of the Engineer or the referee laboratory to deny a referee request upon review of the test reports provided by the Contractor.

Table 2
Number of Allowable Working Days to Report Referee Test Results

Material Property	Test Method	Working Days
Gradation	Tex-110-E, Part I	5
Liquid Limit (Multi-Point Method)	Tex-104-E, Part I	5
Plasticity Index	Tex-106-E	5
Wet Ball Mill Value	Tex-116-E, Parts I and II	5
Wet Ball Mill, % Increase passing #40 sieve		
Compressive Strength ¹	Tex-117-E, Part II	6
Compressive Strength ²	Tex-117-E	12

1. Moisture-Density curve provided by the District
2. Moisture-Density curve determined by the referee laboratory

Section 4.6., "Ride Quality." This section is voided and replaced by the following.

Measurement of ride quality only applies to the final travel lanes that receive a 1- or 2-course surface treatment for the final riding surface, unless otherwise shown on the plans. Measure the ride quality of the base course either before or after the application of the prime coat, as directed, and before placement of the surface treatment. Use a certified profiler operator from the Department's MPL. When requested, furnish the Engineer documentation for the person certified to operate the profiler.

Provide all profile data to the Engineer in electronic data files within 3 days of measuring the ride quality using the format specified in [Tex-1001-S](#). The Engineer will use Department software to evaluate longitudinal profiles to determine areas requiring corrective action. Correct 0.1-mi.sections for each wheel path having an average international roughness index (IRI) value greater than 100 in. per mile to an IRI value of 100 in. per mile or less, unless otherwise shown on the plans.

Re-profile and correct sections that fail to maintain ride quality, as directed. Correct re-profiled sections until specification requirements are met, as approved. Perform this work at no additional expense to the Department.

Special Provision to Item 314

Emulsified Asphalt Treatment



Item 314, "Emulsified Asphalt Treatment" of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Articles 1 through 6 are voided and replaced by the following:

1. DESCRIPTION

Apply a mixture of water and asphalt emulsion as a base or subgrade treatment; for erosion control, including dust prevention; or as a prime coat.

2. MATERIALS

Furnish materials of the type and grade shown on the plans in accordance with the following:

Emulsion. Furnish emulsified asphalt meeting the requirements of Item 300, "Asphalt, Oils, and Emulsions."

Emulsion and Water Mixture. Dilute the emulsion by adding water to create a mixture containing a proportion of emulsion, expressed as a percentage of total volume, in accordance with the percentage shown on the plans or as directed.

3. EQUIPMENT

Provide a self-propelled sprinkler in accordance with Article 204.3., "Equipment." Provide current calibration documentation for the tank used for distribution.

4. CONSTRUCTION

Agitate the emulsion and water mixture to produce a uniform blend. Evenly distribute at the rate selected by the Engineer to locations shown on the plans or as directed.

Base or Subgrade Treatment. Treat the base or subgrade to the depth and width shown on the plans or as directed.

Regulate the percentage of emulsion in the mixture and distribute successive applications to achieve the specified rate. Maintain the proper moisture content of the treated material. Mix the treated material, then shape and compact as required by the specification for the course. Finish the course to the line, grade, and typical section shown on the plans. Maintain the surface with light applications of the mixture while curing the course, as directed.

Erosion Control. Apply the mixture as shown on the plans or as directed.

Prime Coat. Regulate the percentage of emulsion in the mixture and distribute successive applications to achieve the specified rate.

5. MEASUREMENT

The treatment will be measured by the gallon of emulsion used in the emulsion and water mixture.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Emulsified Asphalt (Base or Subgrade Treatment)," "Emulsified Asphalt (Erosion Control)," or "Emulsified Asphalt (Prime Coat)," of the type and grade specified. This price is full compensation for materials, including emulsion and water, and for equipment, labor, tools, and incidentals.

Special Provision to Item 360

Concrete Pavement



Item 360, "Concrete Pavement" of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Section 360.2.1., "Materials," the third paragraph is voided and replaced by the following:

For continuously reinforced concrete pavements, use a coarse aggregate with a rated coefficient of thermal expansion of not more than 5.5×10^{-6} in./in./°F as listed in the Department's *Concrete Rated Source Quality Catalog*.

Section 360.4.8.3., "Surface Texture," the second paragraph is voided and replaced by the following:

A metal-tine texture finish is required unless otherwise shown on the plans. Provide transverse or longitudinal tining unless otherwise shown on the plans. Immediately following the carpet drag, apply a single coat of evaporation retardant, if needed, at the rate recommended by the manufacturer. Provide the metal-tine finish immediately after the concrete surface has set enough for consistent tining. Operate the metal-tine device to obtain grooves approximately 3/16 in. deep, with a minimum depth of 1/8 in., and approximately 1/12 in. wide. Do not overlap a previously tined area. Use manual methods to achieve similar results on ramps, small or irregular areas, and narrow width sections of pavements. Repair damage to the edge of the slab and joints immediately after texturing. Do not tine pavement that will be overlaid or that is scheduled for blanket diamond grinding or shot blasting.

Special Provision to Item 500

Mobilization



Item 500, "Mobilization" of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Section 3, "Payment," The section is removed and replaced by the following:

For this Item, the adjusted Contract amount will be calculated as the total Contract amount less the lump sum for mobilization. Except for Contracts with callout or emergency work, mobilization will be paid in partial payments as follows.

- Payment will be made upon presentation of a paid invoice for the payment or performance bonds and required insurance.
- Payment will be made upon verification of documented expenditures for plant and facility setup. The combined amount for all these facilities will be no more than 10% of the mobilization lump sum or 1% of the total Contract amount, whichever is less.
- When 1% of the adjusted Contract amount for construction Items is earned, 50% of the mobilization lump sum bid will be paid. Previous payments under this Item will be deducted from this amount.
- When 5% of the adjusted Contract amount for construction Items is earned, 75% of the mobilization lump sum bid will be paid. Previous payments under the Item will be deducted from this amount.
- When 10% of the adjusted Contract amount for construction Items is earned, 90% of the mobilization lump sum bid will be paid. Previous payments under this Item will be deducted from this amount.
- Upon final acceptance, 97% of the mobilization lump sum bid will be paid. Previous payments under this Item will be deducted from this amount.
- Payment for the remainder of the lump sum bid for "Mobilization" will be made after all submittals are received, final quantities have been determined and when any separate vegetative establishment and maintenance, test, and performance periods provided for in the Contract have been successfully completed.

For projects with extended maintenance or performance periods, payment for the remainder of the lump sum bid for "Mobilization" will be made 6 mo. after final acceptance.

For Contracts with callout or emergency work, "Mobilization," will be paid as follows.

- Payment will be made upon presentation of a paid invoice for the payment of performance bonds and required insurance.
- Mobilization for callout work will be paid for each callout work request.
- Mobilization for emergency work will be paid for each emergency work request.

Special Provision to Item 465

Junction Boxes, Manholes, and Inlets



Item 465, "Junction Boxes, Manholes, and Inlets," of the Standard Specifications, is hereby amended with respect to the clauses cited below, and no other clauses or requirements of this Item are waived or changed hereby.

Section 2.1., "Concrete," The section is voided and replaced with the following.

Furnish concrete per DMS-7305 for formed and machine-made precast junction boxes, manholes, and inlets. Furnish Class C concrete for cast-in-place junction boxes, manholes, and inlets unless otherwise shown on the plans.

Section 3.1., "Precast Junction Boxes, Manholes, and Inlets," The section is voided and replaced with the following.

Construct formed and machine-made precast junction boxes, manholes, and inlets in accordance with DMS-7305, "Fabrication and Qualification Procedure for Multi-Project Fabrication Plants of Precast Concrete Drainage Structures" and the Contract Plans, except as otherwise noted in this Item.

Multi-project fabrication plants as defined in Item 424 "Precast Concrete Structural Members (Fabrication)," that produce junction boxes, manholes, and inlets will be approved by the Materials and Tests Division in accordance with DMS-7305, "Fabrication and Qualification Procedure for Multi-Project Fabrication Plants of Precast Concrete Drainage Structures." The Department's MPL has a list of approved multi-project fabrication plants.

Section 3.1.1., "Lifting Holes," The section is voided and not replaced.

Section 3.1.2., "Marking," The section is voided and replaced with the following.

Marking. Clearly mark each precast junction box, manhole, and inlet unit with the following information:

- name or trademark of fabricator and plant location;
- product designation;
- ASTM designation (if applicable);
- date of manufacture;
- designation "TX" for precast units fabricated per DMS-7305;
- designated fabricator's approval stamp for each approved unit; and
- designation "SR" for product meeting sulfate-resistant concrete plan requirements (when applicable).

Special Provision to Item 500

Mobilization



Item 500, "Mobilization" of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Section 3, "Payment," The section is removed and replaced by the following:

For this Item, the adjusted Contract amount will be calculated as the total Contract amount less the lump sum for mobilization. Except for Contracts with callout or emergency work, mobilization will be paid in partial payments as follows.

- Payment will be made upon presentation of a paid invoice for the payment or performance bonds and required insurance.
- Payment will be made upon verification of documented expenditures for plant and facility setup. The combined amount for all these facilities will be no more than 10% of the mobilization lump sum or 1% of the total Contract amount, whichever is less.
- When 1% of the adjusted Contract amount for construction Items is earned, 50% of the mobilization lump sum bid will be paid. Previous payments under this Item will be deducted from this amount.
- When 5% of the adjusted Contract amount for construction Items is earned, 75% of the mobilization lump sum bid will be paid. Previous payments under the Item will be deducted from this amount.
- When 10% of the adjusted Contract amount for construction Items is earned, 90% of the mobilization lump sum bid will be paid. Previous payments under this Item will be deducted from this amount.
- Upon final acceptance, 97% of the mobilization lump sum bid will be paid. Previous payments under this Item will be deducted from this amount.
- Payment for the remainder of the lump sum bid for "Mobilization" will be made after all submittals are received, final quantities have been determined and when any separate vegetative establishment and maintenance, test, and performance periods provided for in the Contract have been successfully completed.

For projects with extended maintenance or performance periods, payment for the remainder of the lump sum bid for "Mobilization" will be made 6 mo. after final acceptance.

For Contracts with callout or emergency work, "Mobilization," will be paid as follows.

- Payment will be made upon presentation of a paid invoice for the payment of performance bonds and required insurance.
- Mobilization for callout work will be paid for each callout work request.
- Mobilization for emergency work will be paid for each emergency work request.

Special Provision to Item 502

Barricades, Signs and Traffic Handling



Item 502, "Barricades, Signs and Traffic Handling" of the Standard Specifications, is hereby amended with respect to the clauses cited below, and no other clauses or requirements of this Item are waived or changed hereby.

Article 502.1., "Description," is supplemented by the following:

Temporary work-zone (TWZ) traffic control devices manufactured after December 31, 2019, must have been successfully tested to the crashworthiness requirements of the 2016 edition of the Manual for Assessing Safety Hardware (MASH). Such devices manufactured on or before this date and successfully tested to NCHRP Report 350 or the 2009 edition of MASH may continue to be used throughout their normal service lives. An exception to the manufacture date applies when, based on the project's date of letting, a category of MASH-2016 compliant TWZ traffic control devices are not approved, or are not self-certified after the December 31, 2019, date. In such case, devices that meet NCHRP-350 or MASH-2009 may be used regardless of the manufacture date.

Such TWZ traffic control devices include: portable sign supports, barricades, portable traffic barriers designated exclusively for use in temporary work zones, crash cushions designated exclusively for use in temporary work zones, longitudinal channelizers, truck and trailer mounted attenuators. Category I Devices (i.e., lightweight devices) such as cones, tubular markers and drums without lights or signs attached however, may be self-certified by the vendor or provider, with documentation provided to Department or as are shown on Department's Compliant Work Zone Traffic Control Device List.

Article 502.4., "Payment," is supplemented by the following:

Truck mounted attenuators and trailer attenuators will be paid for under Special Specification, "Truck Mounted Attenuator (TMA) and Trailer Attenuator (TA)." Portable Changeable Message Signs will be paid for under Special Specification, "Portable Changeable Message Sign." Portable Traffic Signals will be paid for under Special Specification, "Portable Traffic Signals."

Special Provision to Item 506

Temporary Erosion, Sedimentation, and Environmental Controls



Item 506, "Temporary Erosion, Sedimentation, and Environmental Controls," of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Article 506.1., "Description." The second paragraph is voided and replaced by the following.

Contractor is considered primary operator to have day-to-day operational control as defined in TPDES GP TXR150000.

- 1.1. For projects with soil disturbance of less than 1 acre, no submittal to TCEQ will be required but Contractor will follow SWP3. For projects with soil disturbance of 1 acre to less than 5 acres a small site notice will be posted at the site. For projects with soil disturbance of 5 acres or more a Notice of Intent (NOI) is required and a large site notice posted at site. Postings will be in accordance with TPDES GP TXR150000. Postings not associated with project specific locations will be in same location as Department's postings.
- 1.2. **Notice of Intent (NOI).** Submit a NOI, if applicable, with the TCEQ under the TPDES GP TXR150000 at least 7 days prior to commencement of construction activities at the project site. Provide a signed copy to the Engineer and any other MS4 operators at the time of submittal. The Department will submit their NOI prior to contractor submission and will provide a copy for Contractor's use in completing the Contractor's NOI form.
- 1.3. **Notice of Change (NOC).** Upon concurrence of the Engineer, submit a NOC, if applicable, to the TCEQ within 14 days of discovery of a change or revision to the NOI as required by the TPDES GP TXR150000. Provide a signed copy of the NOC to the Engineer and any other MS4 operators at the time of submittal.
- 1.4. **Notice of Termination (NOT).** Upon concurrence of the Engineer, submit a NOT, if applicable, to the TCEQ within 30 days of the Engineer's approval that 70% native background vegetative cover is met or equivalent permanent stabilization have been employed in accordance with the TPDES GP TXR 150000. Provide a signed copy of the NOT to the Engineer and any other MS4 operators at the time of submittal.

Section 506.3.1, "Contractor Responsible Person Environmental (CRPE) Qualifications and Responsibilities," is supplemented by the following:

- 3.1. **Contractor Responsible Person Environmental (CRPE) Qualifications and Responsibilities.** Provide and designate in writing at the preconstruction conference a CRPE and alternate CRPE who have overall responsibility for the storm water management program. The CRPE will implement stormwater and erosion control practices; will oversee and observe stormwater control measure monitoring and management; will monitor the project site daily and produce daily monitoring reports as long as there are BMPs in place or soil disturbing activities are evident to ensure compliance with the SWP3 and TPDES General Permit TXR150000. Daily monitor reports shall be maintained and made available upon request. During time suspensions when work is not occurring or on contract non-work days, daily inspections are not required unless a rain event has occurred. The CRPE will provide recommendations on how to improve the effectiveness of control measures. Attend the Department's preconstruction conference for the project. Ensure training is completed as identified in Section 506.3.3., "Training," by all applicable personnel before employees work on the project. Document and maintain and make available upon request, a list, signed by the CRPE, of all applicable Contractor and subcontractor employees who have completed the training. Include the employee's name, the training course name, and date the employee completed the training.

Section 506.3.3., "Training," is supplemented by the following:

Training is provided by the Department at no cost to the Contractor and is valid for 3 yr. from the date of completion. The Engineer may require the following training at a frequency less than 3 yr. based on environmental needs:

- "Environmental Management System: Awareness Training for the Contractor" (English and Spanish) (Approximate running time 20 min.), and
- "Storm Water: Environmental Requirements During Construction" (English and Spanish) (Approximate running time 20 min.).

The Contractor responsible person environmental (CRPE), alternate CRPE designated for emergencies, Contractor's superintendent, Contractor, and subcontractor lead personnel involved in soil disturbing or SWP3 activities must enroll in and complete the training listed below and maintain and make available upon request the certificate of completion. Training is provided by a third party and is valid for 3 yr. from the date shown on the Certificate of Completion. Coordinate enrollment as prescribed by the Department and pay associated fees for the following training:

- "Revegetation During Construction,"
- "Construction General Permit Compliance," and
- "Construction Stage Gate Checklist (CSGC)."

Training and associated fee will not be measured or paid for directly but are subsidiary to this Item.

Special Provision to Item 666

Retroreflectorized Pavement Markings



Item 666, "Retroreflectorized Pavement Markings," of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Section 2.3., "Glass Traffic Beads." The first paragraph is voided and replaced by the following:

Furnish drop-on glass beads in accordance with DMS-8290, "Glass Traffic Beads," or as approved. Furnish a double-drop of Type II and Type III drop-on glass beads for longitudinal pavement markings where each type bead is applied separately in equal portions (by weight), unless otherwise approved. Apply the Type III beads before applying the Type II beads. Furnish Type II beads for work zone pavement markings and transverse markings or symbols.

Section 4.3.1., "Type I Markings.," is supplemented by the following:

4.3.1.3. Spot Striping. Perform spot striping on a callout basis with a minimum callout quantity as shown on the plans.

Section 4.3.2., "Type II Markings.," is supplemented by the following:

4.3.2.1. Spot Striping. Perform spot striping on a callout basis with a minimum callout quantity as shown on the plans.

Section 4.4., "Retroreflectivity Requirements.," is voided and replaced by the following.

Type I markings for Contracts totaling more than 20,000 ft. of pavement markings must meet the following minimum retroreflectivity values for all longitudinal edgeline, centerline or no passing barrier-line, and lane line markings when measured any time after 3 days, but not later than 10 days after application.

- White markings: 250 millicandelas per square meter per lux (mcd/m²/lx)
- Yellow markings: 175 mcd/m²/lx

Retroreflectivity requirements for Type I markings are not required for Contracts with less than 20,000 ft. of pavement markings or Contracts with callout work, unless otherwise shown on the plans.

Section 4.5., "Retroreflectivity Measurements.," is voided and replaced by the following:

Use a mobile retroreflectometer to measure retroreflectivity for Contracts totaling more than 50,000 ft. of pavement markings, unless otherwise shown on the plans. For Contracts with less than 50,000 ft. of pavement markings, mobile or portable retroreflectometers may be used at the Contractor's discretion. Coordinate with and obtain authorization from the Engineer before starting any retroreflectivity data collection.

Section 4.5.1., "Mobile Retroreflectometer Measurements." The last paragraph is voided and replaced by the following.

Restripe again at the Contractor's expense with a minimum of 0.060 in. (60 mils) of Type I marking material if the average of these measurements falls below the minimum retroreflectivity requirements. Take measurements every 0.1 miles a minimum of 10 days after this third application within that mile segment for that series of markings. If the markings do not meet minimum retroreflectivity after this third application, the Engineer may require removal of all existing markings, a new application as initially specified, and a repeat of the application process until minimum retroreflectivity requirements are met.

Section 4.5.2., “Portable Retroreflectometer Measurements.” The first and second paragraphs are voided and replaced by the following.

Provide portable measurement averages for every 1.0 mile unless otherwise specified or approved. Take a minimum of 20 measurements for each 1-mi. section of roadway for each series of markings (e.g., edgeline, center skip line, each line of a double line) and direction of traffic flow when using a portable reflectometer. Measure each line in both directions for centerlines on two-way roadways (i.e., measure both double solid lines in both directions and measure all center skip lines in both directions). The spacing between each measurement must be at least 100 ft. The Engineer may decrease the mileage frequency for measurements if the previous measurements provide satisfactory results. The Engineer may require the original number of measurements if concerns arise.

Restripe at the Contractor's expense with a minimum of 0.060 in. (60 mils) of Type I marking material if the averages of these measurements fail. Take a minimum of 10 more measurements after 10 days of this second application within that mile segment for that series of markings. Restripe again at the Contractor's expense with a minimum of 0.060 in. (60 mils) of Type I marking material if the average of these measurements falls below the minimum retroreflectivity requirements. If the markings do not meet minimum retroreflectivity after this third application, the Engineer may require removal of all existing markings, a new application as initially specified, and a repeat of the application process until minimum retroreflectivity requirements are met.

Section 4.6. “Performance Period.” The first sentence is voided and replaced by the following:

All longitudinal markings must meet the minimum retroreflectivity requirements within the time frame specified. All markings must meet all other performance requirements of this specification for at least 30 calendar days after installation.

Article 6. “Payment.” The first two paragraphs are voided and replaced by the following.

The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Pavement Sealer” of the size specified; “Retroreflectorized Pavement Markings” of the type and color specified and the shape, width, size, and thickness (Type I markings only) specified, as applicable; “Retroreflectorized Pavement Markings with Retroreflective Requirements” of the types, colors, sizes, widths, and thicknesses specified; “Retroreflectorized Profile Pavement Markings” of the various types, colors, shapes, sizes, and widths specified; or “Reflectorized Pavement Marking (Call Out)” of the shape, width, size, and thickness (Type I markings only) specified, as applicable; or “Pavement Sealer (Call Out)” of the size specified.

This price is full compensation for materials, application of pavement markings, equipment, labor, tools, and incidentals.

E. SPECIAL PROVISIONS (CRRMA)

Special Provision 000

Important Notice to Contractors



As of August 24, 2023, utilities within the project limits have not been cleared. The County of El Paso anticipates clearance by the dates listed below. Unless otherwise stated, clearance of these obstructions will be performed by their owners. Estimated clearance dates are not anticipated to interfere with the Contractor's operations. In the event the clearance dates are not met, requests for additional compensation or time will be made in accordance with the standard specifications.

The Contractor is invited to review the mapped information of obstructions on file with the Engineer.

UTILITY				
Utility Owner	Approximate Location	Estimated Completion/Clearance Date	Phase and Phase Start Date	Effect on Construction
El Paso Electric	Hangar Improvements	Prior to Construction	N/A. Coordination with EP Electric will be completed by the contractor prior to begin Construction.	N/A. Coordination with EP Electric will be completed by the contractor prior to begin Construction.

All of the utility companies have been contacted and it has been determined that the above listed dates are valid. The adjustment of utilities in accordance with the above dates will not impede or delay the Contractor in construction of this project.

F. SPECIAL SPECIFICATIONS (TXDOT)

Special Specification 1005

Loose Aggregate for Groundcover



1. DESCRIPTION

Furnish and install loose aggregate for groundcover as shown on the plans or as directed.

2. MATERIALS

Furnish material in accordance with the plans.

3. CONSTRUCTION

Use construction methods in accordance with the plans.

4. MEASUREMENT

This Item will be measured by the cubic yard or square yard of the depth specified.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Loose Aggregate for Groundcover" of type specified. This price is full compensation for furnishing all materials, equipment, labor, and incidentals.

Special Specification 3076

Dense-Graded Hot-Mix Asphalt



1. DESCRIPTION

Construct a hot-mix asphalt (HMA) pavement layer composed of a compacted, dense-graded mixture of aggregate and asphalt binder mixed hot in a mixing plant. Payment adjustments will apply to HMA placed under this specification unless the HMA is deemed exempt in accordance with Section 3076.4.9.4., "Exempt Production."

2. MATERIALS

Furnish uncontaminated materials of uniform quality that meet the requirements of the plans and specifications.

Notify the Engineer of all material sources and before changing any material source or formulation. The Engineer will verify that the specification requirements are met when the Contractor makes a source or formulation change, and may require a new laboratory mixture design, trial batch, or both. The Engineer may sample and test project materials at any time during the project to verify specification compliance in accordance with Item 6, "Control of Materials."

- 3.1 **Aggregate.** Furnish aggregates from sources that conform to the requirements shown in Table 1 and as specified in this Section. Aggregate requirements in this Section, including those shown in Table 1, may be modified or eliminated when shown on the plans. Additional aggregate requirements may be specified when shown on the plans. Provide aggregate stockpiles that meet the definitions in this Section for coarse, intermediate, or fine aggregate. Aggregate from reclaimed asphalt pavement (RAP) is not required to meet Table 1 requirements unless otherwise shown on the plans. Supply aggregates that meet the definitions in [Tex-100-E](#) for crushed gravel or crushed stone. The Engineer will designate the plant or the quarry as the sampling location. Provide samples from materials produced for the project. The Engineer will establish the Surface Aggregate Classification (SAC) and perform Los Angeles abrasion, magnesium sulfate soundness, and Micro-Deval tests. Perform all other aggregate quality tests listed in Table 1. Document all test results on the mixture design report. The Engineer may perform tests on independent or split samples to verify Contractor test results. Stockpile aggregates for each source and type separately. Determine aggregate gradations for mixture design and production testing based on the washed sieve analysis given in [Tex-200-F](#), Part II.

- 2.1.1. **Coarse Aggregate.** Coarse aggregate stockpiles must have no more than 20% material passing the No. 8 sieve. Aggregates from sources listed in the Department's *Bituminous Rated Source Quality Catalog* (BRSQC) are preapproved for use. Use only the rated values for hot-mix listed in the BRSQC. Rated values for surface treatment (ST) do not apply to coarse aggregate sources used in hot-mix asphalt.

For sources not listed on the Department's BRSQC:

- build an individual stockpile for each material;
- request the Department test the stockpile for specification compliance; and
- once approved, do not add material to the stockpile unless otherwise approved.

Provide aggregate from non-listed sources only when tested by the Engineer and approved before use. Allow 30 calendar days for the Engineer to sample, test, and report results for non-listed sources.

Provide coarse aggregate with at least the minimum SAC shown on the plans. SAC requirements only apply to aggregates used on the surface of travel lanes. SAC requirements apply to aggregates used on surfaces

other than travel lanes when shown on the plans. The SAC for sources on the Department's *Aggregate Quality Monitoring Program* (AQMP) ([Tex-499-A](#)) is listed in the BRSQC.

- 2.1.1.1. **Blending Class A and Class B Aggregates.** Class B aggregate meeting all other requirements in Table 1 may be blended with a Class A aggregate to meet requirements for Class A materials, unless otherwise shown on the plans. Ensure that at least 50% by weight, or volume if required, of the material retained on the No. 4 sieve comes from the Class A aggregate source when blending Class A and B aggregates to meet a Class A requirement unless otherwise shown on the plans. Blend by volume if the bulk specific gravities of the Class A and B aggregates differ by more than 0.300. Coarse aggregate from RAP and Recycled Asphalt Shingles (RAS) will be considered as Class B aggregate for blending purposes.

The Engineer may perform tests at any time during production, when the Contractor blends Class A and B aggregates to meet a Class A requirement, to ensure that at least 50% by weight, or volume if required, of the material retained on the No. 4 sieve comes from the Class A aggregate source. The Engineer will use the Department's mix design template, when electing to verify conformance, to calculate the percent of Class A aggregate retained on the No. 4 sieve by inputting the bin percentages shown from readouts in the control room at the time of production and stockpile gradations measured at the time of production. The Engineer may determine the gradations based on either washed or dry sieve analysis from samples obtained from individual aggregate cold feed bins or aggregate stockpiles. The Engineer may perform spot checks using the gradations supplied by the Contractor on the mixture design report as an input for the template; however, a failing spot check will require confirmation with a stockpile gradation determined by the Engineer.

- 2.1.1.2. **Micro-Deval Abrasion.** The Engineer will perform a minimum of one Micro-Deval abrasion test in accordance with [Tex-461-A](#) for each coarse aggregate source used in the mixture design that has a Rated Source Soundness Magnesium (RSSM) loss value greater than 15 as listed in the BRSQC. The Engineer will perform testing before the start of production and may perform additional testing at any time during production. The Engineer may obtain the coarse aggregate samples from each coarse aggregate source or may require the Contractor to obtain the samples. The Engineer may waive all Micro-Deval testing based on a satisfactory test history of the same aggregate source.

The Engineer will estimate the magnesium sulfate soundness loss for each coarse aggregate source, when tested, using the following formula:

$$Mg_{est.} = (RSSM)(MD_{act.}/RSMD)$$

where:

$Mg_{est.}$ = magnesium sulfate soundness loss

$MD_{act.}$ = actual Micro-Deval percent loss

$RSMD$ = Rated Source Micro-Deval

When the estimated magnesium sulfate soundness loss is greater than the maximum magnesium sulfate soundness loss specified, the coarse aggregate source will not be allowed for use unless otherwise approved. The Engineer will consult the Soils and Aggregates Section of the Materials and Tests Division, and additional testing may be required before granting approval.

- 2.1.2. **Intermediate Aggregate.** Aggregates not meeting the definition of coarse or fine aggregate will be defined as intermediate aggregate. Supply intermediate aggregates, when used that are free from organic impurities. The Engineer may test the intermediate aggregate in accordance with [Tex-408-A](#) to verify the material is free from organic impurities. Supply intermediate aggregate from coarse aggregate sources, when used that meet the requirements shown in Table 1 unless otherwise approved.

Test the stockpile if 10% or more of the stockpile is retained on the No. 4 sieve, and verify that it meets the requirements in Table 1 for crushed face count ([Tex-460-A](#)) and flat and elongated particles ([Tex-280-F](#)).

- 2.1.3. **Fine Aggregate.** Fine aggregates consist of manufactured sands, screenings, and field sands. Fine aggregate stockpiles must meet the gradation requirements in Table 2. Supply fine aggregates that are free from organic impurities. The Engineer may test the fine aggregate in accordance with [Tex-408-A](#) to verify the

material is free from organic impurities. Unless otherwise shown on the plans, up to 10% of the total aggregate may be field sand or other uncrushed fine aggregate. Use fine aggregate, with the exception of field sand, from coarse aggregate sources that meet the requirements shown in Table 1 unless otherwise approved.

Test the stockpile if 10% or more of the stockpile is retained on the No. 4 sieve and verify that it meets the requirements in Table 1 for crushed face count ([Tex-460-A](#)) and flat and elongated particles ([Tex-280-F](#)).

Table 1
Aggregate Quality Requirements

Property	Test Method	Requirement
Coarse Aggregate		
SAC	Tex-499-A (AQMP)	As shown on the plans
Deleterious material, %, Max	Tex-217-F , Part I	1.5
Decantation, %, Max	Tex-217-F , Part II	1.5
Micro-Deval abrasion, %	Tex-461-A	Note 1
Los Angeles abrasion, %, Max	Tex-410-A	40
Magnesium sulfate soundness, 5 cycles, %, Max	Tex-411-A	30
Crushed face count, ² %, Min	Tex-460-A , Part I	85
Flat and elongated particles @ 5:1, %, Max	Tex-280-F	10
Fine Aggregate		
Linear shrinkage, %, Max	Tex-107-E	3
Sand equivalent, %, Min	Tex-203-F	45

1. Used to estimate the magnesium sulfate soundness loss in accordance with Section 3076.2.1.1.2., "Micro-Deval Abrasion."
2. Only applies to crushed gravel.

Table 2
Gradation Requirements for Fine Aggregate

Sieve Size	% Passing by Weight or Volume
3/8"	100
#8	70–100
#200	0–30

3.2

Mineral Filler. Mineral filler consists of finely divided mineral matter such as agricultural lime, crusher fines, hydrated lime, or fly ash. Mineral filler is allowed unless otherwise shown on the plans. Use no more than 2% hydrated lime or fly ash unless otherwise shown on the plans. Use no more than 1% hydrated lime if a substitute binder is used unless otherwise shown on the plans or allowed. Test all mineral fillers except hydrated lime and fly ash in accordance with [Tex-107-E](#) to ensure specification compliance. The plans may require or disallow specific mineral fillers. Provide mineral filler, when used, that:

- is sufficiently dry, free-flowing, and free from clumps and foreign matter as determined by the Engineer;
- does not exceed 3% linear shrinkage when tested in accordance with [Tex-107-E](#); and
- meets the gradation requirements in Table 3, unless otherwise shown on the plans.

Table 3
Gradation Requirements for Mineral Filler

Sieve Size	% Passing by Weight or Volume
#8	100
#200	55–100

3.3

Baghouse Fines. Fines collected by the baghouse or other dust-collecting equipment may be reintroduced into the mixing drum.

3.4

Asphalt Binder. Furnish the type and grade of performance-graded (PG) asphalt specified on the plans.

3.5

Tack Coat. Furnish CSS-1H, SS-1H, or a PG binder with a minimum high-temperature grade of PG 58 for tack coat binder in accordance with Item 300, "Asphalts, Oils, and Emulsions." Specialized tack coat

materials listed on the Department's MPL are allowed or required when shown on the plans. Do not dilute emulsified asphalts at the terminal, in the field, or at any other location before use.

- 3.6 **Additives.** Use the type and rate of additive specified when shown on the plans. Additives that facilitate mixing, compaction, or improve the quality of the mixture are allowed when approved. Provide the Engineer with documentation such as the bill of lading showing the quantity of additives used in the project unless otherwise directed.

- 2.6.1. **Lime and Liquid Antistripping Agent.** When lime or a liquid antistripping agent is used, add in accordance with Item 301, "Asphalt Antistripping Agents." Do not add lime directly into the mixing drum of any plant where lime is removed through the exhaust stream unless the plant has a baghouse or dust collection system that reintroduces the lime into the drum.

- 2.6.2. **Warm Mix Asphalt (WMA).** Warm Mix Asphalt (WMA) is defined as HMA that is produced within a target temperature discharge range of 215°F and 275°F using approved WMA additives or processes from the Department's MPL.

WMA is allowed for use on all projects and is required when shown on the plans. When WMA is required, the maximum placement or target discharge temperature for WMA will be set at a value below 275°F.

Department-approved WMA additives or processes may be used to facilitate mixing and compaction of HMA produced at target discharge temperatures above 275°F; however, such mixtures will not be defined as WMA.

- 2.6.3. **Compaction Aid.** Compaction Aid is defined as a chemical warm mix additive that is used to produce an asphalt mixture at a discharge temperature greater than 275°F.

Compaction Aid is allowed for use on all projects and is required when shown on the plans.

- 3.7 **Recycled Materials.** Use of RAP and RAS is permitted unless otherwise shown on the plans. Use of RAS is restricted to only intermediate and base mixes unless otherwise shown on the plans. Do not exceed the maximum allowable percentages of RAP and RAS shown in Table 4. The allowable percentages shown in Table 4 may be decreased or increased when shown on the plans. Determine the asphalt binder content and gradation of the RAP and RAS stockpiles for mixture design purposes in accordance with [Tex-236-F](#), Part I. The Engineer may verify the asphalt binder content of the stockpiles at any time during production. Perform other tests on RAP and RAS when shown on the plans. Asphalt binder from RAP and RAS is designated as recycled asphalt binder. Calculate and ensure that the ratio of the recycled asphalt binder to total binder does not exceed the percentages shown in Table 5 during mixture design and HMA production when RAP or RAS is used. Use a separate cold feed bin for each stockpile of RAP and RAS during HMA production.

Surface, intermediate, and base mixes referenced in Tables 4 and 5 are defined as follows:

- **Surface.** The final HMA lift placed at the top of the pavement structure or placed directly below mixtures produced in accordance with Items 316, 342, 347, or 348;
- **Intermediate.** Mixtures placed below an HMA surface mix and less than or equal to 8.0 in. from the riding surface; and
- **Base.** Mixtures placed greater than 8.0 in. from the riding surface. Unless otherwise shown on the plans, mixtures used for bond breaker are defined as base mixtures.

- 2.7.1. **RAP.** RAP is salvaged, milled, pulverized, broken, or crushed asphalt pavement. Fractionated RAP is defined as a stockpile that contains RAP material with a minimum of 95.0% passing the 3/8-in. or 1/2-in. sieve, before burning in the ignition oven, unless otherwise approved. The Engineer may allow the Contractor to use an alternate to the 3/8-in. or 1/2-in. screen to fractionate the RAP.

Use of Contractor-owned RAP including HMA plant waste is permitted unless otherwise shown on the plans. Department-owned RAP stockpiles are available for the Contractor's use when the stockpile locations are

shown on the plans. If Department-owned RAP is available for the Contractor's use, the Contractor may use Contractor-owned fractionated RAP and replace it with an equal quantity of Department-owned RAP. Department-owned RAP generated through required work on the Contract is available for the Contractor's use when shown on the plans. Perform any necessary tests to ensure Contractor- or Department-owned RAP is appropriate for use. The Department will not perform any tests or assume any liability for the quality of the Department-owned RAP unless otherwise shown on the plans. The Contractor will retain ownership of RAP generated on the project when shown on the plans.

Do not use Department- or Contractor-owned RAP contaminated with dirt or other objectionable materials. Do not use Department- or Contractor-owned RAP if the decantation value exceeds 5% and the plasticity index is greater than 8. Test the stockpiled RAP for decantation in accordance with [Tex-406-A](#), Part I. Determine the plasticity index in accordance with [Tex-106-E](#) if the decantation value exceeds 5%. The decantation and plasticity index requirements do not apply to RAP samples with asphalt removed by extraction or ignition.

Do not intermingle Contractor-owned RAP stockpiles with Department-owned RAP stockpiles. Remove unused Contractor-owned RAP material from the project site upon completion of the project. Return unused Department-owned RAP to the designated stockpile location.

Table 4
Maximum Allowable Amounts of RAP¹

Maximum Allowable Fractionated RAP (%)		
Surface	Intermediate	Base
15.0	25.0	30.0

1. Must also meet the recycled binder to total binder ratio shown in Table 5.

2.7.2.

RAS. Use of post-manufactured RAS or post-consumer RAS (tear-offs) is not permitted in surface mixtures unless otherwise shown on the plans. RAS may be used in intermediate and base mixtures unless otherwise shown on the plans. Up to 3% RAS may be used separately or as a replacement for fractionated RAP in accordance with Table 4 and Table 5. RAS is defined as processed asphalt shingle material from manufacturing of asphalt roofing shingles or from re-roofing residential structures. Post-manufactured RAS is processed manufacturer's shingle scrap by-product. Post-consumer RAS is processed shingle scrap removed from residential structures. Comply with all regulatory requirements stipulated for RAS by the TCEQ. RAS may be used separately or in conjunction with RAP.

Process the RAS by ambient grinding or granulating such that 100% of the particles pass the 3/8 in. sieve when tested in accordance with [Tex-200-F](#), Part I. Perform a sieve analysis on processed RAS material before extraction (or ignition) of the asphalt binder.

Add sand meeting the requirements of Table 1 and Table 2 or fine RAP to RAS stockpiles if needed to keep the processed material workable. Any stockpile that contains RAS will be considered a RAS stockpile and be limited to no more than 3.0% of the HMA mixture in accordance with Table 4.

Certify compliance of the RAS with [DMS-11000](#), "Evaluating and Using Nonhazardous Recyclable Materials Guidelines." Treat RAS as an established nonhazardous recyclable material if it has not come into contact with any hazardous materials. Use RAS from shingle sources on the Department's MPL. Remove substantially all materials before use that are not part of the shingle, such as wood, paper, metal, plastic, and felt paper. Determine the deleterious content of RAS material for mixture design purposes in accordance with [Tex-217-F](#), Part III. Do not use RAS if deleterious materials are more than 0.5% of the stockpiled RAS unless otherwise approved. Submit a sample for approval before submitting the mixture design. The Department will perform the testing for deleterious material of RAS to determine specification compliance.

3.8

Substitute Binders. Unless otherwise shown on the plans, the Contractor may use a substitute PG binder listed in Table 5 instead of the PG binder originally specified, if using recycled materials, and if the substitute PG binder and mixture made with the substitute PG binder meet the following:

- the substitute binder meets the specification requirements for the substitute binder grade in accordance with Section 300.2.10., “Performance-Graded Binders;” and
- the mixture has less than 10.0 mm of rutting on the Hamburg Wheel test ([Tex-242-F](#)) after the number of passes required for the originally specified binder. Use of substitute PG binders may only be allowed at the discretion of the Engineer if the Hamburg Wheel test results are between 10.0 mm and 12.5 mm.

Table 5
Allowable Substitute PG Binders and Maximum Recycled Binder Ratios

Originally Specified PG Binder	Allowable Substitute PG Binder for Surface Mixes	Allowable Substitute PG Binder for Intermediate and Base Mixes	Maximum Ratio of Recycled Binder ¹ to Total Binder (%)		
			Surface	Intermediate	Base
76-22 ^{4,5}	70-22	70-22	10.0	20.0	25.0
70-22 ^{2,5}	N/A	64-22	10.0	20.0	25.0
64-22 ^{2,3}	N/A	N/A	10.0	20.0	25.0
76-28 ^{4,5}	70-28	70-28	10.0	20.0	25.0
70-28 ^{2,5}	N/A	64-28	10.0	20.0	25.0
64-28 ^{2,3}	N/A	N/A	10.0	20.0	25.0

1. Combined recycled binder from RAP and RAS. RAS is not permitted in surface mixtures unless otherwise shown on the plans.
2. Binder substitution is not allowed for surface mixtures.
3. Binder substitution is not allowed for intermediate and base mixtures.
4. Use no more than 10.0% recycled binder in surface mixtures when using this originally specified PG binder.
5. Use no more than 20.0% recycled binder when using this originally specified PG binder for intermediate mixtures. Use no more than 25.0% recycled binder when using this originally specified PG binder for base mixtures.

3. EQUIPMENT

Provide required or necessary equipment in accordance with Item 320, “Equipment for Asphalt Concrete Pavement.”

4. CONSTRUCTION

Produce, haul, place, and compact the specified paving mixture. In addition to tests required by the specification, Contractors may perform other QC tests as deemed necessary. At any time during the project, the Engineer may perform production and placement tests as deemed necessary in accordance with Item 5, “Control of the Work.” Schedule and participate in a mandatory pre-paving meeting with the Engineer on or before the first day of paving unless otherwise shown on the plans.

3.1

Certification. Personnel certified by the Department-approved hot-mix asphalt certification program must conduct all mixture designs, sampling, and testing in accordance with Table 6. Supply the Engineer with a list of certified personnel and copies of their current certificates before beginning production and when personnel changes are made. Provide a mixture design developed and signed by a Level 2 certified specialist. Provide Level 1A certified specialists at the plant during production operations. Provide Level 1B certified specialists to conduct placement tests. Provide AGG101 certified specialists for aggregate testing.

Table 6
Test Methods, Test Responsibility, and Minimum Certification Levels

Test Description	Test Method	Contractor	Engineer	Level ¹
1. Aggregate and Recycled Material Testing				
Sampling	Tex-221-F	✓	✓	1A/AGG101
Dry sieve	Tex-200-F , Part I	✓	✓	1A/AGG101
Washed sieve	Tex-200-F , Part II	✓	✓	1A/AGG101
Deleterious material	Tex-217-F , Parts I & III	✓	✓	AGG101
Decantation	Tex-217-F , Part II	✓	✓	AGG101
Los Angeles abrasion	Tex-410-A		✓	TxDOT
Magnesium sulfate soundness	Tex-411-A		✓	TxDOT
Micro-Deval abrasion	Tex-461-A		✓	AGG101
Crushed face count	Tex-460-A	✓	✓	AGG101
Flat and elongated particles	Tex-280-F	✓	✓	AGG101
Linear shrinkage	Tex-107-E	✓	✓	AGG101
Sand equivalent	Tex-203-F	✓	✓	AGG101
Organic impurities	Tex-408-A	✓	✓	AGG101
2. Asphalt Binder & Tack Coat Sampling				
Asphalt binder sampling	Tex-500-C , Part II	✓	✓	1A/1B
Tack coat sampling	Tex-500-C , Part III	✓	✓	1A/1B
3. Mix Design & Verification				
Design and JMF changes	Tex-204-F	✓	✓	2
Mixing	Tex-205-F	✓	✓	2
Molding (TGC)	Tex-206-F	✓	✓	1A
Molding (SGC)	Tex-241-F	✓	✓	1A
Laboratory-molded density	Tex-207-F , Parts I & VI	✓	✓	1A
Rice gravity	Tex-227-F , Part II	✓	✓	1A
Ignition oven correction factors ²	Tex-236-F , Part II	✓	✓	2
Indirect tensile strength	Tex-226-F	✓	✓	1A
Hamburg Wheel test	Tex-242-F	✓	✓	1A
Boil test	Tex-530-C	✓	✓	1A
4. Production Testing				
Selecting production random numbers	Tex-225-F , Part I		✓	1A
Mixture sampling	Tex-222-F	✓	✓	1A/1B
Molding (TGC)	Tex-206-F	✓	✓	1A
Molding (SGC)	Tex-241-F	✓	✓	1A
Laboratory-molded density	Tex-207-F , Parts I & VI	✓	✓	1A
Rice gravity	Tex-227-F , Part II	✓	✓	1A
Gradation & asphalt binder content ²	Tex-236-F , Part I	✓	✓	1A
Control charts	Tex-233-F	✓	✓	1A
Moisture content	Tex-212-F , Part II	✓	✓	1A/AGG101
Hamburg Wheel test	Tex-242-F	✓	✓	1A
Micro-Deval abrasion	Tex-461-A		✓	AGG101
Boil test	Tex-530-C	✓	✓	1A
Abson recovery	Tex-211-F		✓	TxDOT
5. Placement Testing				
Selecting placement random numbers	Tex-225-F , Part II		✓	1B
Trimming roadway cores	Tex-251-F , Parts I & II	✓	✓	1A/1B
In-place air voids	Tex-207-F , Parts I & VI	✓	✓	1A
In-place density (nuclear method)	Tex-207-F , Part III	✓		1B
Establish rolling pattern	Tex-207-F , Part IV	✓		1B
Control charts	Tex-233-F	✓	✓	1A
Ride quality measurement	Tex-1001-S	✓	✓	Note 3
Segregation (density profile)	Tex-207-F , Part V	✓	✓	1B
Longitudinal joint density	Tex-207-F , Part VII	✓	✓	1B
Thermal profile	Tex-244-F	✓	✓	1B
Shear Bond Strength Test	Tex-249-F		✓	TxDOT

Test Description	Test Method	Contractor	Engineer	Level ¹
1.	Level 1A, 1B, AGG101, and 2 are certification levels provided by the Hot Mix Asphalt Center certification program.			
2.	Refer to Section 3076.4.9.2.3., "Production Testing," for exceptions to using an ignition oven.			
3.	Profiler and operator are required to be certified at the Texas A&M Transportation Institute facility when Surface Test Type B is specified.			

3.2

Reporting and Responsibilities. Use Department-provided templates to record and calculate all test data, including mixture design, production and placement QC/QA, control charts, thermal profiles, segregation density profiles, and longitudinal joint density. Obtain the current version of the templates at <http://www.txdot.gov/inside-txdot/forms-publications/consultants-contractors/forms/site-manager.html> or from the Engineer. The Engineer and the Contractor will provide any available test results to the other party when requested. The maximum allowable time for the Contractor and Engineer to exchange test data is as given in Table 7 unless otherwise approved. The Engineer and the Contractor will immediately report to the other party any test result that requires suspension of production or placement, a payment adjustment less than 1.000, or that fails to meet the specification requirements. Record and electronically submit all test results and pertinent information on Department-provided templates.

Subsequent sublots placed after test results are available to the Contractor, which require suspension of operations, may be considered unauthorized work. Unauthorized work will be accepted or rejected at the discretion of the Engineer in accordance with Article 5.3., "Conformity with Plans, Specifications, and Special Provisions."

Table 7
Reporting Schedule

Reporting Schedule			
Description	Reported By	Reported To	To Be Reported Within
Production Quality Control			
Gradation ¹	Contractor	Engineer	1 working day of completion of the subplot
Asphalt binder content ¹			
Laboratory-molded density ²			
Moisture content ³			
Boil test ³			
Production Quality Assurance			
Gradation ³	Engineer	Contractor	1 working day of completion of the subplot
Asphalt binder content ³			
Laboratory-molded density ¹			
Hamburg Wheel test ⁴			
Boil test ³			
Binder tests ⁴			
Placement Quality Control			
In-place air voids ²	Contractor	Engineer	1 working day of completion of the lot
Segregation ¹			
Longitudinal joint density ¹			
Thermal profile ¹			
Placement Quality Assurance			
In-place air voids ¹	Engineer	Contractor	1 working day after receiving the trimmed cores ⁵
Segregation ³			1 working day of completion of the lot
Longitudinal joint density ³			
Thermal profile ³			
Aging ratio ⁴			
Payment adjustment summary	Engineer	Contractor	2 working days of performing all required tests and receiving Contractor test data

1. These tests are required on every subplot.
2. Optional test. When performed on split samples, report the results as soon as they become available.
3. To be performed at the frequency specified in Table 16 or as shown on the plans.
4. To be reported as soon as the results become available.
5. 2 days are allowed if cores cannot be dried to constant weight within 1 day.

The Engineer will use the Department-provided template to calculate all payment adjustment factors for the lot. Sublot samples may be discarded after the Engineer and Contractor sign off on the payment adjustment summary documentation for the lot.

Use the procedures described in [Tex-233-F](#) to plot the results of all quality control (QC) and quality assurance (QA) testing. Update the control charts as soon as test results for each subplot become available. Make the control charts readily accessible at the field laboratory. The Engineer may suspend production for failure to update control charts.

3.3

Quality Control Plan (QCP). Develop and follow the QCP in detail. Obtain approval for changes to the QCP made during the project. The Engineer may suspend operations if the Contractor fails to comply with the QCP.

Submit a written QCP before the mandatory pre-paving meeting. Receive approval of the QCP before beginning production. Include the following items in the QCP:

2.3.1. **Project Personnel.** For project personnel, include:

- a list of individuals responsible for QC with authority to take corrective action;
- current contact information for each individual listed; and
- current copies of certification documents for individuals performing specified QC functions.

2.3.2. **Material Delivery and Storage.** For material delivery and storage, include:

- the sequence of material processing, delivery, and minimum quantities to assure continuous plant operations;
- aggregate stockpiling procedures to avoid contamination and segregation;
- frequency, type, and timing of aggregate stockpile testing to assure conformance of material requirements before mixture production; and
- procedure for monitoring the quality and variability of asphalt binder.

2.3.3. **Production.** For production, include:

- loader operation procedures to avoid contamination in cold bins;
- procedures for calibrating and controlling cold feeds;
- procedures to eliminate debris or oversized material;
- procedures for adding and verifying rates of each applicable mixture component (e.g., aggregate, asphalt binder, RAP, RAS, lime, liquid antistripping, WMA);
- procedures for reporting job control test results; and
- procedures to avoid segregation and drain-down in the silo.

2.3.4. **Loading and Transporting.** For loading and transporting, include:

- type and application method for release agents; and
- truck loading procedures to avoid segregation.

2.3.5. **Placement and Compaction.** For placement and compaction, include:

- proposed agenda for mandatory pre-paving meeting, including date and location;
- proposed paving plan (e.g., paving widths, joint offsets, and lift thicknesses);
- type and application method for release agents in the paver and on rollers, shovels, lutes, and other utensils;
- procedures for the transfer of mixture into the paver, while avoiding segregation and preventing material spillage;
- process to balance production, delivery, paving, and compaction to achieve continuous placement operations and good ride quality;
- paver operations (e.g., operation of wings, height of mixture in auger chamber) to avoid physical and thermal segregation and other surface irregularities; and
- procedures to construct quality longitudinal and transverse joints.

3.4 **Mixture Design.**

2.4.1. **Design Requirements.** The Contractor will design the mixture using a Superpave Gyratory Compactor (SGC). A Texas Gyratory Compactor (TGC) may be used when shown on the plans. Use the dense-graded design procedure provided in [Tex-204-F](#). Design the mixture to meet the requirements listed in Tables 1, 2, 3, 4, 5, 8, 9, and 10.

2.4.1.1. **Design Number of Gyration (Ndesign) When The SGC Is Used.** Design the mixture at 50 gyrations (Ndesign). Use a target laboratory-molded density of 96.0% to design the mixture; however, adjustments can be made to the Ndesign value as noted in Table 9. The Ndesign level may be reduced to at least 35 gyrations at the Contractor's discretion.

Use an approved laboratory from the Department's MPL to perform the Hamburg Wheel test, and provide results with the mixture design, or provide the laboratory mixture and request that the Department perform the Hamburg Wheel test. The Engineer will be allowed 10 working days to provide the Contractor with Hamburg Wheel test results on the laboratory mixture design.

The Engineer will provide the mixture design when shown on the plans. The Contractor may submit a new mixture design at any time during the project. The Engineer will verify and approve all mixture designs (JMF1) before the Contractor can begin production.

Provide the Engineer with a mixture design report using the Department-provided template. Include the following items in the report:

- the combined aggregate gradation, source, specific gravity, and percent of each material used;
- asphalt binder content and aggregate gradation of RAP and RAS stockpiles;
- the target laboratory-molded density (or Ndesign level when using the SGC);
- results of all applicable tests;
- the mixing and molding temperatures;
- the signature of the Level 2 person or persons that performed the design;
- the date the mixture design was performed; and
- a unique identification number for the mixture design.

Table 8
Master Gradation Limits (% Passing by Weight or Volume) and VMA Requirements

Sieve Size	B Fine Base	C Coarse Surface	D Fine Surface	F Fine Mixture
2"	—	—	—	—
1-1/2"	100.0 ¹	—	—	—
1"	98.0–100.0	100.0 ¹	—	—
3/4"	84.0–98.0	95.0–100.0	100.0 ¹	—
1/2"	—	—	98.0–100.0	100.0 ¹
3/8"	60.0–80.0	70.0–85.0	85.0–100.0	98.0–100.0
#4	40.0–60.0	43.0–63.0	50.0–70.0	70.0–90.0
#8	29.0–43.0	32.0–44.0	35.0–46.0	38.0–48.0
#30	13.0–28.0	14.0–28.0	15.0–29.0	12.0–27.0
#50	6.0–20.0	7.0–21.0	7.0–20.0	6.0–19.0
#200	2.0–7.0	2.0–7.0	2.0–7.0	2.0–7.0
Design VMA, % Minimum				
—	13.0	14.0	15.0	16.0
Production (Plant-Produced) VMA, % Minimum				
—	12.5	13.5	14.5	15.5

1. Defined as maximum sieve size. No tolerance allowed.

Table 9
Laboratory Mixture Design Properties

Mixture Property	Test Method	Requirement
Target laboratory-molded density, % (SGC)	Tex-207-F	96.0
Design gyrations (N _{design} for SGC)	Tex-241-F	50 ¹
Indirect tensile strength (dry), psi	Tex-226-F	85–200 ²
Boil test ³	Tex-530-C	–

1. Adjust within a range of 35–100 gyrations when shown on the plans or specification or when mutually agreed between the Engineer and Contractor.
2. The Engineer may allow the IDT strength to exceed 200 psi if the corresponding Hamburg Wheel rut depth is greater than 3.0 mm and less than 12.5 mm.
3. Used to establish baseline for comparison to production results. May be waived when approved.

Table 10
Hamburg Wheel Test Requirements

High-Temperature Binder Grade	Test Method	Minimum # of Passes @ 12.5 mm ¹ Rut Depth, Tested @ 50°C
PG 64 or lower	Tex-242-F	10,000 ²
PG 70		15,000 ³
PG 76 or higher		20,000

1. When the rut depth at the required minimum number of passes is less than 3 mm, the Engineer may require the Contractor to increase the target laboratory-molded density (TGC) by 0.5% to no more than 97.5% or lower the N_{design} level (SGC) to at least 35 gyrations.
2. May be decreased to at least 5,000 passes when shown on the plans.
3. May be decreased to at least 10,000 passes when shown on the plans.

2.4.1.2. **Target Laboratory-Molded Density When The TGC Is Used.** Design the mixture at a 96.5% target laboratory-molded density. Increase the target laboratory-molded density to 97.0% or 97.5% at the Contractor's discretion or when shown on the plans or specification.

2.4.2. **Job-Mix Formula Approval.** The job-mix formula (JMF) is the combined aggregate gradation, target laboratory-molded density (or N_{design} level), and target asphalt percentage used to establish target values for hot-mix production. JMF1 is the original laboratory mixture design used to produce the trial batch. When WMA is used, JMF1 may be designed and submitted to the Engineer without including the WMA additive. When WMA is used, document the additive or process used and recommended rate on the JMF1 submittal. The Engineer and the Contractor will verify JMF1 based on plant-produced mixture from the trial batch unless otherwise approved. The Engineer may accept an existing mixture design previously used on a Department project and may waive the trial batch to verify JMF1. The Department may require the Contractor to reimburse the Department for verification tests if more than 2 trial batches per design are required.

2.4.2.1. **Contractor's Responsibilities.**

2.4.2.1.1. **Providing Gyratory Compactor.** Use a SGC calibrated in accordance with [Tex-241-F](#) to design the mixture in accordance with [Tex-204-F](#), Part IV, for molding production samples. Locate the SGC, if used, at the Engineer's field laboratory and make the SGC available to the Engineer for use in molding production samples. Furnish a TGC calibrated in accordance with [Tex-914-K](#) when shown on the plans to design the mixture in accordance with [Tex-204-F](#), Part I, for molding production samples.

2.4.2.1.2. **Gyratory Compactor Correlation Factors.** Use [Tex-206-F](#), Part II, to perform a gyratory compactor correlation when the Engineer uses a different gyratory compactor. Apply the correlation factor to all subsequent production test results.

2.4.2.1.3. **Submitting JMF1.** Furnish a mix design report (JMF1) with representative samples of all component materials and request approval to produce the trial batch. Provide approximately 10,000 g of the design

mixture if opting to have the Department perform the Hamburg Wheel test on the laboratory mixture, and request that the Department perform the test.

- 2.4.2.1.4. **Supplying Aggregates.** Provide approximately 40 lb. of each aggregate stockpile unless otherwise directed.
- 2.4.2.1.5. **Supplying Asphalt.** Provide at least 1 gal. of the asphalt material and enough quantities of any additives proposed for use.
- 2.4.2.1.6. **Ignition Oven Correction Factors.** Determine the aggregate and asphalt correction factors from the ignition oven in accordance with [Tex-236-F](#), Part II. Provide correction factors that are not more than 12 months old. Provide the Engineer with split samples of the mixtures before the trial batch production, including all additives (except water), and blank samples used to determine the correction factors for the ignition oven used for QA testing during production. Correction factors established from a previously approved mixture design may be used for the current mixture design if the mixture design and ignition oven are the same as previously used, unless otherwise directed.
- 2.4.2.1.7. **Boil Test.** Perform the test and retain the tested sample from [Tex-530-C](#) until completion of the project or as directed. Use this sample for comparison purposes during production. The Engineer may waive the requirement for the boil test.
- 2.4.2.1.8. **Trial Batch Production.** Provide a plant-produced trial batch upon receiving conditional approval of JMF1 and authorization to produce a trial batch, including the WMA additive or process if applicable, for verification testing of JMF1 and development of JMF2. Produce a trial batch mixture that meets the requirements in Table 4, Table 5, and Table 11. The Engineer may accept test results from recent production of the same mixture instead of a new trial batch.
- 2.4.2.1.9. **Trial Batch Production Equipment.** Use only equipment and materials proposed for use on the project to produce the trial batch.
- 2.4.2.1.10. **Trial Batch Quantity.** Produce enough quantity of the trial batch to ensure that the mixture meets the specification requirements.
- 2.4.2.1.11. **Number of Trial Batches.** Produce trial batches as necessary to obtain a mixture that meets the specification requirements.
- 2.4.2.1.12. **Trial Batch Sampling.** Obtain a representative sample of the trial batch and split it into 3 equal portions in accordance with [Tex-222-F](#). Label these portions as "Contractor," "Engineer," and "Referee." Deliver samples to the appropriate laboratory as directed.
- 2.4.2.1.13. **Trial Batch Testing.** Test the trial batch to ensure the mixture produced using the proposed JMF1 meets the mixture requirements in Table 11. Ensure the trial batch mixture is also in compliance with the Hamburg Wheel requirement in Table 10. Use a Department-approved laboratory to perform the Hamburg Wheel test on the trial batch mixture or request that the Department perform the Hamburg Wheel test. The Engineer will be allowed 10 working days to provide the Contractor with Hamburg Wheel test results on the trial batch. Provide the Engineer with a copy of the trial batch test results.
- 2.4.2.1.14. **Development of JMF2.** Evaluate the trial batch test results after the Engineer grants full approval of JMF1 based on results from the trial batch, determine the optimum mixture proportions, and submit as JMF2. Adjust the asphalt binder content or gradation to achieve the specified target laboratory-molded density. The asphalt binder content established for JMF2 is not required to be within any tolerance of the optimum asphalt binder content established for JMF1; however, mixture produced using JMF2 must meet the voids in mineral aggregates (VMA) requirements for production shown in Table 8. If the optimum asphalt binder content for JMF2 is more than 0.5% lower than the optimum asphalt binder content for JMF1, the Engineer may perform or require the Contractor to perform [Tex-226-F](#) on Lot 1 production to confirm the indirect tensile strength does not exceed 200 psi. Verify that JMF2 meets the mixture requirements in Table 5.

- 2.4.2.1.15. **Mixture Production.** Use JMF2 to produce Lot 1 as described in Section 3076.4.9.3.1.1., “Lot 1 Placement,” after receiving approval for JMF2 and a passing result from the Department’s or a Department-approved laboratory’s Hamburg Wheel test on the trial batch. If desired, proceed to Lot 1 production, once JMF2 is approved, at the Contractor’s risk without receiving the results from the Department’s Hamburg Wheel test on the trial batch.

Notify the Engineer if electing to proceed without Hamburg Wheel test results from the trial batch. Note that the Engineer may require up to the entire subplot of any mixture failing the Hamburg Wheel test to be removed and replaced at the Contractor’s expense.

- 2.4.2.1.16. **Development of JMF3.** Evaluate the test results from Lot 1, determine the optimum mixture proportions, and submit as JMF3 for use in Lot 2.

- 2.4.2.1.17. **JMF Adjustments.** If JMF adjustments are necessary to achieve the specified requirements, make the adjustments before beginning a new lot. The adjusted JMF must:

- be provided to the Engineer in writing before the start of a new lot;
- be numbered in sequence to the previous JMF;
- meet the mixture requirements in Table 4 and Table 5;
- meet the master gradation limits shown in Table 8; and
- be within the operational tolerances of JMF2 listed in Table 11.

- 2.4.2.1.18. **Requesting Referee Testing.** Use referee testing, if needed, in accordance with Section 3076.4.9.1., “Referee Testing,” to resolve testing differences with the Engineer.

Table 11
Operational Tolerances

Description	Test Method	Allowable Difference Between Trial Batch and JMF1 Target	Allowable Difference from Current JMF Target	Allowable Difference between Contractor and Engineer ¹
Individual % retained for #8 sieve and larger	Tex-200-F or Tex-236-F	Must be Within Master Grading Limits in Table 8	±5.0 ^{2,3}	±5.0
Individual % retained for sieves smaller than #8 and larger than #200			±3.0 ^{2,3}	±3.0
% passing the #200 sieve			±2.0 ^{2,3}	±1.6
Asphalt binder content, %	Tex-236-F	±0.5	±0.3 ³	±0.3
Laboratory-molded density, %	Tex-207-F	±1.0	±1.0	±1.0
In-place air voids, %		N/A	N/A	±1.0
Laboratory-molded bulk specific gravity		N/A	N/A	±0.020
VMA, %, min	Tex-204-F	Note ⁴	Note ⁴	N/A
Theoretical maximum specific (Rice) gravity	Tex-227-F	N/A	N/A	±0.020

1. Contractor may request referee testing only when values exceed these tolerances.
2. When within these tolerances, mixture production gradations may fall outside the master grading limits; however, the % passing the #200 will be considered out of tolerance when outside the master grading limits.
3. Only applies to mixture produced for Lot 1 and higher.
4. Test and verify that Table 8 requirements are met.

2.4.2.2. **Engineer’s Responsibilities.**

- 2.4.2.2.1. **Gyratory Compactor.** For SGC mixtures designed in accordance with [Tex-204-F](#), Part IV, the Engineer will use a Department SGC, calibrated in accordance with [Tex-241-F](#), to mold samples for laboratory mixture design verification. For molding trial batch and production specimens, the Engineer will use the Contractor-provided SGC at the field laboratory or provide and use a Department SGC at an alternate location. The Engineer will make the Contractor-provided SGC in the Department field laboratory available to the Contractor for molding verification samples.

For TGC mixtures designed in accordance with [Tex-204-F](#), Part I, the Engineer will use a Department TGC, calibrated in accordance with [Tex-914-K](#), to mold samples for trial batch and production testing. The

Engineer will make the Department TGC and the Department field laboratory available to the Contractor for molding verification samples, if requested by the Contractor.

2.4.2.2.2. **Conditional Approval of JMF1 and Authorizing Trial Batch.** The Engineer will review and verify conformance of the following information within 2 working days of receipt:

- the Contractor's mix design report (JMF1);
- the Contractor-provided Hamburg Wheel test results;
- all required materials including aggregates, asphalt, additives, and recycled materials; and
- the mixture specifications.

The Engineer will grant the Contractor conditional approval of JMF1 if the information provided on the paper copy of JMF1 indicates that the Contractor's mixture design meets the specifications. When the Contractor does not provide Hamburg Wheel test results with laboratory mixture design, 10 working days are allowed for conditional approval of JMF1. The Engineer will base full approval of JMF1 on the test results on mixture from the trial batch.

Unless waived, the Engineer will determine the Micro-Deval abrasion loss in accordance with Section 3076.2.1.1.2., "Micro-Deval Abrasion." If the Engineer's test results are pending after two working days, conditional approval of JMF1 will still be granted within two working days of receiving JMF1. When the Engineer's test results become available, they will be used for specification compliance.

After conditionally approving JMF1, including either Contractor- or Department-supplied Hamburg Wheel test results, the Contractor is authorized to produce a trial batch.

2.4.2.2.3. **Hamburg Wheel Testing of JMF1.** If the Contractor requests the option to have the Department perform the Hamburg Wheel test on the laboratory mixture, the Engineer will mold samples in accordance with [Tex-242-F](#) to verify compliance with the Hamburg Wheel test requirement in Table 10.

2.4.2.2.4. **Ignition Oven Correction Factors.** The Engineer will use the split samples provided by the Contractor to determine the aggregate and asphalt correction factors for the ignition oven used for QA testing during production in accordance with [Tex-236-F](#), Part II. Provide correction factors that are not more than 12 months old.

2.4.2.2.5. **Testing the Trial Batch.** Within 1 full working day, the Engineer will sample and test the trial batch to ensure that the mixture meets the requirements in Table 11. If the Contractor requests the option to have the Department perform the Hamburg Wheel test on the trial batch mixture, the Engineer will mold samples in accordance with [Tex-242-F](#) to verify compliance with the Hamburg Wheel test requirement in Table 10.

The Engineer will have the option to perform the following tests on the trial batch:

- [Tex-226-F](#), to verify that the indirect tensile strength meets the requirement shown in Table 9; and
- [Tex-530-C](#), to retain and use for comparison purposes during production.

2.4.2.2.6. **Full Approval of JMF1.** The Engineer will grant full approval of JMF1 and authorize the Contractor to proceed with developing JMF2 if the Engineer's results for the trial batch meet the requirements in Table 11. The Engineer will notify the Contractor that an additional trial batch is required if the trial batch does not meet these requirements.

2.4.2.2.7. **Approval of JMF2.** The Engineer will approve JMF2 within one working day if the mixture meets the requirements in Table 5 and the gradation meets the master grading limits shown in Table 8. The asphalt binder content established for JMF2 is not required to be within any tolerance of the optimum asphalt binder content established for JMF1; however, mixture produced using JMF2 must meet the VMA requirements shown in Table 8. If the optimum asphalt binder content for JMF2 is more than 0.5% lower than the optimum

asphalt binder content for JMF1, the Engineer may perform or require the Contractor to perform [Tex-226-F](#) on Lot 1 production to confirm the indirect tensile strength does not exceed 200 psi.

- 2.4.2.2.8. **Approval of Lot 1 Production.** The Engineer will authorize the Contractor to proceed with Lot 1 production (using JMF2) as soon as a passing result is achieved from the Department's or a Department-approved laboratory's Hamburg Wheel test on the trial batch. The Contractor may proceed at its own risk with Lot 1 production without the results from the Hamburg Wheel test on the trial batch.

If the Department's or Department-approved laboratory's sample from the trial batch fails the Hamburg Wheel test, the Engineer will suspend production until further Hamburg Wheel tests meet the specified values. The Engineer may require up to the entire subplot of any mixture failing the Hamburg Wheel test be removed and replaced at the Contractor's expense.

- 2.4.2.2.9. **Approval of JMF3 and Subsequent JMF Changes.** JMF3 and subsequent JMF changes are approved if they meet the mixture requirements shown in Table 4, Table 5, and the master grading limits shown in Table 8, and are within the operational tolerances of JMF2 shown in Table 11.

- 3.5 **Production Operations.** Perform a new trial batch when the plant or plant location is changed. Take corrective action and receive approval to proceed after any production suspension for noncompliance to the specification. Submit a new mix design and perform a new trial batch when the asphalt binder content of:
- any RAP stockpile used in the mix is more than 0.5% higher than the value shown on the mixture design report; or
 - RAS stockpile used in the mix is more than 2.0% higher than the value shown on the mixture design report.

- 2.5.1. **Storage and Heating of Materials.** Do not heat the asphalt binder above the temperatures specified in Item 300, "Asphalts, Oils, and Emulsions," or outside the manufacturer's recommended values. Provide the Engineer with daily records of asphalt binder and hot-mix asphalt discharge temperatures (in legible and discernible increments) in accordance with Item 320, "Equipment for Asphalt Concrete Pavement," unless otherwise directed. Do not store mixture for a period long enough to affect the quality of the mixture, nor in any case longer than 12 hr. unless otherwise approved.

- 2.5.2. **Mixing and Discharge of Materials.** Notify the Engineer of the target discharge temperature and produce the mixture within 25°F of the target. Monitor the temperature of the material in the truck before shipping to ensure that it does not exceed the maximum production temperatures listed in Table 12 (or 275°F for WMA). The Department will not pay for or allow placement of any mixture produced above the maximum production temperatures listed in Table 12.

Table 12
Maximum Production Temperature

High-Temperature Binder Grade ¹	Maximum Production Temperature
PG 64	325°F
PG 70	335°F
PG 76	345°F

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.

Produce WMA within the target discharge temperature range of 215°F and 275°F when WMA is required. Take corrective action any time the discharge temperature of the WMA exceeds the target discharge range. The Engineer may suspend production operations if the Contractor's corrective action is not successful at controlling the production temperature within the target discharge range. Note that when WMA is produced, it may be necessary to adjust burners to ensure complete combustion such that no burner fuel residue remains in the mixture.

Control the mixing time and temperature so that substantially all moisture is removed from the mixture before discharging from the plant. Determine the moisture content, if requested, by oven-drying in accordance with [Tex-212-F](#), Part II, and verify that the mixture contains no more than 0.2% of moisture by weight. Obtain the sample immediately after discharging the mixture into the truck, and perform the test promptly.

- 3.6 **Hauling Operations.** Clean all truck beds before use to ensure that mixture is not contaminated. Use a release agent shown on the Department's MPL to coat the inside bed of the truck when necessary.

Use equipment for hauling as defined in Section 3076.4.7.3.3., "Hauling Equipment." Use other hauling equipment only when allowed.

- 3.7 **Placement Operations.** Collect haul tickets from each load of mixture delivered to the project and provide the Department's copy to the Engineer approximately every hour, or as directed. Use a hand-held thermal camera or infrared thermometer, when a thermal imaging system is not used, to measure and record the internal temperature of the mixture as discharged from the truck or Material Transfer Device (MTD) before or as the mix enters the paver and an approximate station number or GPS coordinates on each ticket. Calculate the daily yield and cumulative yield for the specified lift and provide to the Engineer at the end of paving operations for each day unless otherwise directed. The Engineer may suspend production if the Contractor fails to produce and provide haul tickets and yield calculations by the end of paving operations for each day.

Prepare the surface by removing raised pavement markers and objectionable material such as moisture, dirt, sand, leaves, and other loose impediments from the surface before placing mixture. Remove vegetation from pavement edges. Place the mixture to meet the typical section requirements and produce a smooth, finished surface with a uniform appearance and texture. Offset longitudinal joints of successive courses of hot-mix by at least 6 in. Place mixture so that longitudinal joints on the surface course coincide with lane lines and are not placed in the wheel path, or as directed. Ensure that all finished surfaces will drain properly. Place the mixture at the rate or thickness shown on the plans. The Engineer will use the guidelines in Table 13 to determine the compacted lift thickness of each layer when multiple lifts are required. The thickness determined is based on the rate of 110 lb./sq. yd. for each inch of pavement unless otherwise shown on the plans.

Table 13
Compacted Lift Thickness and Required Core Height

Mixture Type	Compacted Lift Thickness Guidelines		Minimum Untrimmed Core Height (in.) Eligible for Testing
	Minimum (in.)	Maximum (in.)	
B	2.50	5.00	1.75
C	2.00	4.00	1.50
D	1.50	3.00	1.25
F	1.25	2.50	1.25

- 2.7.1. **Weather Conditions.**

- 2.7.1.1. **When Using a Thermal Imaging System.** Place mixture when the roadway surface is dry and the roadway surface temperature is at or above the temperatures listed in Table 14A. The Engineer may restrict the Contractor from paving surface mixtures if the ambient temperature is likely to drop below 32°F within 12 hr. of paving. Place mixtures only when weather conditions and moisture conditions of the roadway surface are suitable as determined by the Engineer. Provide output data from the thermal imaging system to demonstrate to the Engineer that no recurring severe thermal segregation exists in accordance with Section 3076.4.7.3.1.2., "Thermal Imaging System."

Table 14A
Minimum Pavement Surface Temperatures

High-Temperature Binder Grade ¹	Minimum Pavement Surface Temperatures (°F)	
	Subsurface Layers or Night Paving Operations	Surface Layers Placed in Daylight Operations

PG 64	35	40
PG 70	45 ²	50 ²
PG 76	45 ²	50 ²

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.
2. Contractors may pave at temperatures 10°F lower than these values when a chemical WMA additive is used as a compaction aid in the mixture or when using WMA.

2.7.1.2.

When Not Using a Thermal Imaging System. When using a thermal camera instead of the thermal imaging system, place mixture when the roadway surface temperature is at or above the temperatures listed in Table 14B unless otherwise approved or as shown on the plans. Measure the roadway surface temperature with a hand-held thermal camera or infrared thermometer. The Engineer may allow mixture placement to begin before the roadway surface reaches the required temperature if conditions are such that the roadway surface will reach the required temperature within 2 hr. of beginning placement operations. Place mixtures only when weather conditions and moisture conditions of the roadway surface are suitable as determined by the Engineer. The Engineer may restrict the Contractor from paving if the ambient temperature is likely to drop below 32°F within 12 hr. of paving.

Table 14B
Minimum Pavement Surface Temperatures

High-Temperature Binder Grade ¹	Minimum Pavement Surface Temperatures (°F)	
	Subsurface Layers or Night Paving Operations	Surface Layers Placed in Daylight Operations
PG 64	45	50
PG 70	55 ²	60 ²
PG 76	60 ²	60 ²

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.
2. Contractors may pave at temperatures 10°F lower than these values when a chemical WMA additive is used as a compaction aid in the mixture, when using WMA, or utilizing a paving process with equipment that eliminates thermal segregation. In such cases, for each sublot and in the presence of the Engineer, use a hand-held thermal camera operated in accordance with [Tex-244-F](#) to demonstrate to the satisfaction of the Engineer that the uncompacted mat has no more than 10°F of thermal segregation.

2.7.2.

Tack Coat.

2.7.2.1.

Application. Clean the surface before placing the tack coat. The Engineer will set the rate between 0.04 and 0.10 gal. of residual asphalt per square yard of surface area. Apply a uniform tack coat at the specified rate unless otherwise directed. Apply the tack coat in a uniform manner to avoid streaks and other irregular patterns. Apply the tack coat to all surfaces that will come in contact with the subsequent HMA placement, unless otherwise directed. Allow adequate time for emulsion to break completely before placing any material. Prevent splattering of tack coat when placed adjacent to curb, gutter, and structures. Do not dilute emulsified asphalts at the terminal, in the field, or at any other location before use.

2.7.2.2.

Sampling. The Engineer will obtain at least one sample of the tack coat binder per project in accordance with [Tex-500-C](#), Part III, and test it to verify compliance with Item 300, "Asphalts, Oils, and Emulsions." The Engineer will notify the Contractor when the sampling will occur and will witness the collection of the sample from the asphalt distributor immediately before use.

For emulsions, the Engineer may test as often as necessary to ensure the residual of the emulsion is greater than or equal to the specification requirement in Item 300, "Asphalts, Oils, and Emulsions."

2.7.3.

Lay-Down Operations. Use the placement temperatures in Table 15 to establish the minimum placement temperature of the mixture delivered to the paver.

Table 15
Minimum Mixture Placement Temperature

High-Temperature Binder Grade¹	Minimum Placement Temperature (Before Entering Paver)^{2,3}
PG 64	260°F
PG 70	270°F
PG 76	280°F

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.
2. Minimum placement temperatures may be reduced 10°F if using a chemical WMA additive as a compaction aid.
3. When using WMA, the minimum placement temperature is 215°F.

- 2.7.3.1. **Thermal Profile.** Use a hand-held thermal camera or a thermal imaging system to obtain a continuous thermal profile in accordance with [Tex-244-F](#). Thermal profiles are not applicable in areas described in Section 3076.4.9.3.1.4., "Miscellaneous Areas."
- 2.7.3.1.1. **Thermal Segregation.**
- 4.7.3.1.1.1. **Moderate.** Any areas that have a temperature differential greater than 25°F, but not exceeding 50°F, are deemed as moderate thermal segregation.
- 4.7.3.1.1.2. **Severe.** Any areas that have a temperature differential greater than 50°F are deemed as severe thermal segregation.
- 2.7.3.1.2. **Thermal Imaging System.** Review the output results when a thermal imaging system is used, and provide the automated report described in [Tex-244-F](#) to the Engineer daily unless otherwise directed. Modify the paving process as necessary to eliminate any recurring (moderate or severe) thermal segregation identified by the thermal imaging system. The Engineer may suspend paving operations if the Contractor cannot successfully modify the paving process to eliminate recurring severe thermal segregation. Density profiles are not required and not applicable when using a thermal imaging system. Provide the Engineer with electronic copies of all daily data files that can be used with the thermal imaging system software to generate temperature profile plots daily or upon completion of the project or as requested by the Engineer.
- 2.7.3.1.3. **Thermal Camera.** When using a thermal camera instead of the thermal imaging system, take immediate corrective action to eliminate recurring moderate thermal segregation when a hand-held thermal camera is used. Evaluate areas with moderate thermal segregation by performing density profiles in accordance with Section 3076.4.9.3.3.2., "Segregation (Density Profile)." Provide the Engineer with the thermal profile of every subplot within one working day of the completion of each lot. When requested by the Engineer, provide the thermal images generated using the thermal camera. Report the results of each thermal profile in accordance with Section 3076.4.2., "Reporting and Responsibilities." The Engineer will use a hand-held thermal camera to obtain a thermal profile at least once per project. No production or placement payment adjustments greater than 1.000 will be paid for any subplot that contains severe thermal segregation. Suspend operations and take immediate corrective action to eliminate severe thermal segregation unless otherwise directed. Resume operations when the Engineer determines that subsequent production will meet the requirements of this Section. Evaluate areas with severe thermal segregation by performing density profiles in accordance with Section 3076.4.9.3.3.2., "Segregation (Density Profile)." Remove and replace the material in any areas that have both severe thermal segregation and a failing result for Segregation (Density Profile) unless otherwise directed. The subplot in question may receive a production and placement payment adjustment greater than 1.000, if applicable, when the defective material is successfully removed and replaced.
- 2.7.3.2. **Windrow Operations.** Operate windrow pickup equipment so that when hot-mix is placed in windrows, substantially all the mixture deposited on the roadbed is picked up and loaded into the paver.
- 2.7.3.3. **Hauling Equipment.** Use belly dumps, live bottom, or end dump trucks to haul and transfer mixture; however, with exception of paving miscellaneous areas, end dump trucks are only allowed when used in

conjunction with an MTD with remixing capability or when a thermal imaging system is used unless otherwise allowed.

- 2.7.3.4. **Screed Heaters.** Turn off screed heaters to prevent overheating of the mat if the paver stops for more than 5 min. The Engineer may evaluate the suspect area in accordance with Section 3076.4.9.3.3.4., "Recovered Asphalt Dynamic Shear Rheometer (DSR)," if the screed heater remains on for more than 5 min. while the paver is stopped.

- 3.8 **Compaction.** Compact the pavement uniformly to contain between 3.8% and 8.5% in-place air voids. Take immediate corrective action to bring the operation within 3.8% and 8.5% when the in-place air voids exceed the range of these tolerances. The Engineer will allow paving to resume when the proposed corrective action is likely to yield between 3.8% and 8.5% in-place air voids.

Obtain cores in areas placed under Exempt Production, as directed, at locations determined by the Engineer. The Engineer may test these cores and suspend operations or require removal and replacement if the in-place air voids are less than 2.7% or more than 9.9%. Areas defined in Section 3076.4.9.3.1.4., "Miscellaneous Areas," are not subject to in-place air void determination.

Furnish the type, size, and number of rollers required for compaction as approved. Use additional rollers as required to remove any roller marks. Use only water or an approved release agent on rollers, tamps, and other compaction equipment unless otherwise directed.

Use the control strip method shown in [Tex-207-F](#), Part IV, on the first day of production to establish the rolling pattern that will produce the desired in-place air voids unless otherwise directed.

Use tamps to thoroughly compact the edges of the pavement along curbs, headers, and similar structures and in locations that will not allow thorough compaction with rollers. The Engineer may require rolling with a trench roller on widened areas, in trenches, and in other limited areas.

Complete all compaction operations before the pavement temperature drops below 160°F unless otherwise allowed. The Engineer may allow compaction with a light finish roller operated in static mode for pavement temperatures below 160°F.

Allow the compacted pavement to cool to 160°F or lower before opening to traffic unless otherwise directed. Sprinkle the finished mat with water or limewater, when directed, to expedite opening the roadway to traffic.

- 3.9 **Acceptance Plan.** Payment adjustments for the material will be in accordance with Article 3076.6., "Payment."

Sample and test the hot-mix on a lot and subplot basis. Suspend production until test results or other information indicates to the satisfaction of the Engineer that the next material produced or placed will result in payment factors of at least 1.000, if the production payment factor given in Section 3076.6.1., "Production Payment Adjustment Factors," for two consecutive lots or the placement pay factor given in Section 3076.6.2., "Placement Payment Adjustment Factors," for two consecutive lots is below 1.000.

- 2.9.1. **Referee Testing.** The Materials and Tests Division is the referee laboratory. The Contractor may request referee testing if a "remove and replace" condition is determined based on the Engineer's test results, or if the differences between Contractor and Engineer test results exceed the maximum allowable difference shown in Table 11 and the differences cannot be resolved. The Contractor may also request referee testing if the Engineer's test results require suspension of production and the Contractor's test results are within specification limits. Make the request within five working days after receiving test results and cores from the Engineer. Referee tests will be performed only on the subplot in question and only for the particular tests in question. Allow 10 working days from the time the referee laboratory receives the samples for test results to be reported. The Department may require the Contractor to reimburse the Department for referee tests if more than three referee tests per project are required and the Engineer's test results are closer to the referee test results than the Contractor's test results.

The Materials and Tests Division will determine the laboratory-molded density based on the molded specific gravity and the maximum theoretical specific gravity of the referee sample. The in-place air voids will be determined based on the bulk specific gravity of the cores, as determined by the referee laboratory and the Engineer's average maximum theoretical specific gravity for the lot. With the exception of "remove and replace" conditions, referee test results are final and will establish payment adjustment factors for the subplot in question. The Contractor may decline referee testing and accept the Engineer's test results when the placement payment adjustment factor for any subplot results in a "remove and replace" condition. Placement sublots subject to be removed and replaced will be further evaluated in accordance with Section 3076.6.2.2., "Placement Sublots Subject to Removal and Replacement."

2.9.2. **Production Acceptance.**

2.9.2.1. **Production Lot.** A production lot consists of four equal sublots. The default quantity for Lot 1 is 1,000 tons; however, when requested by the Contractor, the Engineer may increase the quantity for Lot 1 to no more than 4,000 tons. The Engineer will select subsequent lot sizes based on the anticipated daily production such that approximately three to four sublots are produced each day. The lot size will be between 1,000 tons and 4,000 tons. The Engineer may change the lot size before the Contractor begins any lot.

If the optimum asphalt binder content for JMF2 is more than 0.5% lower than the optimum asphalt binder content for JMF1, the Engineer may perform or require the Contractor to perform [Tex-226-F](#) on Lot 1 to confirm the indirect tensile strength does not exceed 200 psi. Take corrective action to bring the mixture within specification compliance if the indirect tensile strength exceeds 200 psi unless otherwise directed.

2.9.2.1.1. **Incomplete Production Lots.** If a lot is begun but cannot be completed, such as on the last day of production or in other circumstances deemed appropriate, the Engineer may close the lot. Adjust the payment for the incomplete lot in accordance with Section 3076.6.1., "Production Payment Adjustment Factors." Close all lots within five working days unless otherwise allowed.

2.9.2.2. **Production Sampling.**

2.9.2.2.1. **Mixture Sampling.** Obtain hot-mix samples from trucks at the plant in accordance with [Tex-222-F](#). The sampler will split each sample into three equal portions in accordance with [Tex-200-F](#) and label these portions as "Contractor," "Engineer," and "Referee." The Engineer will perform or witness the sample splitting and take immediate possession of the samples labeled "Engineer" and "Referee." The Engineer will maintain the custody of the samples labeled "Engineer" and "Referee" until the Department's testing is completed.

4.9.2.2.1.1. **Random Sample.** At the beginning of the project, the Engineer will select random numbers for all production sublots. Determine sample locations in accordance with [Tex-225-F](#). Take one sample for each subplot at the randomly selected location. The Engineer will perform or witness the sampling of production sublots.

4.9.2.2.1.2. **Blind Sample.** For one subplot per lot, the Engineer will obtain and test a "blind" sample instead of the random sample collected by the Contractor. Test either the "blind" or the random sample; however, referee testing (if applicable) will be based on a comparison of results from the "blind" sample. The location of the Engineer's "blind" sample will not be disclosed to the Contractor. The Engineer's "blind" sample may be randomly selected in accordance with [Tex-225-F](#) for any subplot or selected at the discretion of the Engineer. The Engineer will use the Contractor's split sample for sublots not sampled by the Engineer.

2.9.2.2.2. **Informational Shear Bond Strength Testing.** Select one random subplot from Lot 2 or higher for shear bond strength testing. Obtain full depth cores in accordance with [Tex-249-F](#). Label the cores with the Control Section Job (CSJ), producer of the tack coat, mix type, shot rate, lot, and subplot number and provide to the Engineer. The Engineer will ship the cores to the Materials and Tests Division or district laboratory for shear bond strength testing. Results from these tests will not be used for specification compliance.

2.9.2.2.3. **Asphalt Binder Sampling.** Obtain a 1-qt. sample of the asphalt binder witnessed by the Engineer for each lot of mixture produced. The Contractor will notify the Engineer when the sampling will occur. Obtain the sample at approximately the same time the mixture random sample is obtained. Sample from a port located immediately upstream from the mixing drum or pug mill and upstream from the introduction of any additives

in accordance with [Tex-500-C](#), Part II. Label the can with the corresponding lot and subplot numbers, producer, producer facility location, grade, district, date sampled, and project information including highway and CSJ. The Engineer will retain these samples for one year. The Engineer may also obtain independent samples. If obtaining an independent asphalt binder sample and upon request of the Contractor, the Engineer will split a sample of the asphalt binder with the Contractor.

At least once per project, the Engineer will collect split samples of each binder grade and source used. The Engineer will submit one split sample to MTD to verify compliance with Item 300, "Asphalts, Oils, and Emulsions" and will retain the other split sample for one year.

2.9.2.3.

Production Testing. The Contractor and Engineer must perform production tests in accordance with Table 16. The Contractor has the option to verify the Engineer's test results on split samples provided by the Engineer. Determine compliance with operational tolerances listed in Table 11 for all sublots.

Take immediate corrective action if the Engineer's laboratory-molded density on any subplot is less than 95.0% or greater than 97.0% to bring the mixture within these tolerances. The Engineer may suspend operations if the Contractor's corrective actions do not produce acceptable results. The Engineer will allow production to resume when the proposed corrective action is likely to yield acceptable results.

The Engineer may allow alternate methods for determining the asphalt binder content and aggregate gradation if the aggregate mineralogy is such that [Tex-236-F](#), Part I does not yield reliable results. Provide evidence that results from [Tex-236-F](#), Part I are not reliable before requesting permission to use an alternate method unless otherwise directed. Use the applicable test procedure as directed if an alternate test method is allowed.

Table 16
Production and Placement Testing Frequency

Description	Test Method	Minimum Contractor Testing Frequency	Minimum Engineer Testing Frequency
Individual % retained for #8 sieve and larger	Tex-200-F or Tex-236-F	1 per subplot	1 per 12 sublots ¹
Individual % retained for sieves smaller than #8 and larger than #200			
% passing the #200 sieve			
Laboratory-molded density	Tex-207-F	N/A	1 per subplot ¹
Laboratory-molded bulk specific gravity			
In-place air voids			
VMA	Tex-204-F		
Segregation (density profile) ²	Tex-207-F , Part V	1 per subplot	1 per project
Longitudinal joint density	Tex-207-F , Part VII		
Moisture content	Tex-212-F , Part II	When directed	
Theoretical maximum specific (Rice) gravity	Tex-227-F	N/A	1 per subplot ¹
Asphalt binder content	Tex-236-F	1 per subplot	1 per lot ¹
Hamburg Wheel test	Tex-242-F	N/A	1 per project
Recycled Asphalt Shingles (RAS) ³	Tex-217-F , Part III	N/A	
Thermal profile ²	Tex-244-F	1 per subplot	
Asphalt binder sampling and testing	Tex-500-C , Part II	1 per lot (sample only) ⁴	
Tack coat sampling and testing	Tex-500-C , Part III	N/A	
Boil test ⁵	Tex-530-C	1 per lot	
Shear Bond Strength Test ⁶	Tex-249-F	1 per project (sample only)	

1. For production defined in Section 3076.4.9.4., "Exempt Production," the Engineer will test one per day if 100 tons or more are produced. For Exempt Production, no testing is required when less than 100 tons are produced.
2. Not required when a thermal imaging system is used.
3. Testing performed by the Materials and Tests Division or designated laboratory.
4. Obtain witnessed by the Engineer. The Engineer will retain these samples for one year.
5. The Engineer may reduce or waive the sampling and testing requirements based on a satisfactory test history.
6. Testing performed by the Materials and Tests Division or District for informational purposes only.

2.9.2.4. **Operational Tolerances.** Control the production process within the operational tolerances listed in Table 11. When production is suspended, the Engineer will allow production to resume when test results or other information indicates the next mixture produced will be within the operational tolerances.

2.9.2.4.1. **Gradation.** Suspend operation and take corrective action if any aggregate is retained on the maximum sieve size shown in Table 8. A subplot is defined as out of tolerance if either the Engineer's or the Contractor's test results are out of operational tolerance. Suspend production when test results for gradation exceed the operational tolerances in Table 11 for three consecutive sublots on the same sieve or four consecutive sublots on any sieve unless otherwise directed. The consecutive sublots may be from more than one lot.

2.9.2.4.2. **Asphalt Binder Content.** A subplot is defined as out of operational tolerance if either the Engineer's or the Contractor's test results exceed the values listed in Table 11. No production or placement payment adjustments greater than 1.000 will be paid for any subplot that is out of operational tolerance for asphalt binder content. Suspend production and shipment of the mixture if the Engineer's or the Contractor's asphalt binder content deviates from the current JMF by more than 0.5% for any subplot.

2.9.2.4.3. **Voids in Mineral Aggregates (VMA).** The Engineer will determine the VMA for every subplot. For sublots when the Engineer does not determine asphalt binder content, the Engineer will use the asphalt binder content results from QC testing performed by the Contractor to determine VMA.

Take immediate corrective action if the VMA value for any subplot is less than the minimum VMA requirement for production listed in Table 8. Suspend production and shipment of the mixture if the Engineer's VMA

results on two consecutive sublots are below the minimum VMA requirement for production listed in Table 8. No production or placement payment adjustments greater than 1.000 will be paid for any subplot that does not meet the minimum VMA requirement for production listed in Table 8 based on the Engineer's VMA determination.

Suspend production and shipment of the mixture if the Engineer's VMA result is more than 0.5% below the minimum VMA requirement for production listed in Table 8. In addition to suspending production, the Engineer may require removal and replacement or may allow the subplot to be left in place without payment.

- 2.9.2.4.4. **Hamburg Wheel Test.** The Engineer may perform a Hamburg Wheel test at any time during production, including when the boil test indicates a change in quality from the materials submitted for JMF1. In addition to testing production samples, the Engineer may obtain cores and perform Hamburg Wheel tests on any areas of the roadway where rutting is observed. Suspend production until further Hamburg Wheel tests meet the specified values when the production or core samples fail the Hamburg Wheel test criteria in Table 10. Core samples, if taken, will be obtained from the center of the finished mat or other areas excluding the vehicle wheel paths. The Engineer may require up to the entire subplot of any mixture failing the Hamburg Wheel test to be removed and replaced at the Contractor's expense.

If the Department's or Department approved laboratory's Hamburg Wheel test results in a "remove and replace" condition, the Contractor may request that the Department confirm the results by re-testing the failing material. The Materials and Tests Division will perform the Hamburg Wheel tests and determine the final disposition of the material in question based on the Department's test results.

- 2.9.2.5. **Individual Loads of Hot-Mix.** The Engineer can reject individual truckloads of hot-mix. When a load of hot-mix is rejected for reasons other than temperature, contamination, or excessive uncoated particles, the Contractor may request that the rejected load be tested. Make this request within 4 hr. of rejection. The Engineer will sample and test the mixture. If test results are within the operational tolerances shown in Table 11, payment will be made for the load. If test results are not within operational tolerances, no payment will be made for the load.

2.9.3. **Placement Acceptance.**

- 2.9.3.1. **Placement Lot.** A placement lot consists of four placement sublots. A placement subplot consists of the area placed during a production subplot.

- 2.9.3.1.1. **Lot 1 Placement.** Placement payment adjustments greater than 1.000 for Lot 1 will be in accordance with Section 3076.6.2., "Placement Payment Adjustment Factors"; however, no placement adjustment less than 1.000 will be assessed for any subplot placed in Lot 1 when the in-place air voids are greater than or equal to 2.7% and less than or equal to 9.9%. Remove and replace any subplot with in-place air voids less than 2.7% or greater than 9.9%.

- 2.9.3.1.2. **Incomplete Placement Lots.** An incomplete placement lot consists of the area placed as described in Section 3076.4.9.2.1.1., "Incomplete Production Lots," excluding areas defined in Section 3076.4.9.3.1.4., "Miscellaneous Areas." Placement sampling is required if the random sample plan for production resulted in a sample being obtained from an incomplete production subplot.

- 2.9.3.1.3. **Shoulders, Ramps, Etc.** Shoulders, ramps, intersections, acceleration lanes, deceleration lanes, and turn lanes are subject to in-place air void determination and payment adjustments unless designated on the plans as not eligible for in-place air void determination. Intersections may be considered miscellaneous areas when determined by the Engineer.

- 2.9.3.1.4. **Miscellaneous Areas.** Miscellaneous areas include areas that typically involve significant handwork or discontinuous paving operations, such as temporary detours, driveways, mailbox turnouts, crossovers, gores, spot level-up areas, and other similar areas. Temporary detours are subject to in-place air void determination when shown on the plans. Miscellaneous areas also include level-ups and thin overlays when the layer thickness specified on the plans is less than the minimum untrimmed core height eligible for testing shown in Table 13. The specified layer thickness is based on the rate of 110 lb./sq. yd. for each inch of

pavement unless another rate is shown on the plans. When "level up" is listed as part of the item bid description code, a payment adjustment factor of 1.000 will be assigned for all placement sublots as described in Article 3076.6, "Payment." Miscellaneous areas are not eligible for random placement sampling locations. Compact miscellaneous areas in accordance with Section 3076.4.8., "Compaction." Miscellaneous areas are not subject to in-place air void determination, thermal profiles testing, segregation (density profiles), or longitudinal joint density evaluations.

2.9.3.2.

Placement Sampling. The Engineer will select random numbers for all placement sublots at the beginning of the project. The Engineer will provide the Contractor with the placement random numbers immediately after the subplot is completed. Mark the roadway location at the completion of each subplot and record the station number. Determine one random sample location for each placement subplot in accordance with [Tex-225-F](#). Adjust the random sample location by no more than necessary to achieve a 2-ft. clearance if the location is within 2 ft. of a joint or pavement edge.

Shoulders, ramps, intersections, acceleration lanes, deceleration lanes, and turn lanes are always eligible for selection as a random sample location; however, if a random sample location falls on one of these areas and the area is designated on the plans as not subject to in-place air void determination, cores will not be taken for the subplot and a 1.000 pay factor will be assigned to that subplot.

Provide the equipment and means to obtain and trim roadway cores on site. On-site is defined as in close proximity to where the cores are taken. Obtain the cores within one working day of the time the placement subplot is completed unless otherwise approved. Obtain two 6-in. diameter cores side-by-side from within 1 ft. of the random location provided for the placement subplot. For Type D and Type F mixtures, 4-in. diameter cores are allowed. Mark the cores for identification, measure and record the untrimmed core height, and provide the information to the Engineer. The Engineer will witness the coring operation and measurement of the core thickness. Visually inspect each core and verify that the current paving layer is bonded to the underlying layer. Take corrective action if an adequate bond does not exist between the current and underlying layer to ensure that an adequate bond will be achieved during subsequent placement operations.

Trim the cores immediately after obtaining the cores from the roadway in accordance with [Tex-251-F](#) if the core heights meet the minimum untrimmed value listed in Table 13. Trim the cores on site in the presence of the Engineer. Use a permanent marker or paint pen to record the lot and subplot numbers on each core as well as the designation as Core A or B. The Engineer may require additional information to be marked on the core and may choose to sign or initial the core. The Engineer will take custody of the cores immediately after witnessing the trimming of the cores and will retain custody of the cores until the Department's testing is completed. Before turning the trimmed cores over to the Engineer, the Contractor may wrap the trimmed cores or secure them in a manner that will reduce the risk of possible damage occurring during transport by the Engineer. After testing, the Engineer will return the cores to the Contractor.

The Engineer may have the cores transported back to the Department's laboratory at the HMA plant via the Contractor's haul truck or other designated vehicle. In such cases where the cores will be out of the Engineer's possession during transport, the Engineer will use Department-provided security bags and the Roadway Core Custody protocol located at <http://www.txdot.gov/business/specifications.htm> to provide a secure means and process that protects the integrity of the cores during transport.

Decide whether to include the pair of cores in the air void determination for that subplot if the core height before trimming is less than the minimum untrimmed value shown in Table 13. Trim the cores as described above before delivering to the Engineer if electing to have the cores included in the air void determination. Deliver untrimmed cores to the Engineer and inform the Engineer of the decision to not have the cores included in air void determination if electing to not have the cores included in air void determination. The placement pay factor for the subplot will be 1.000 if cores will not be included in air void determination.

Instead of the Contractor trimming the cores on site immediately after coring, the Engineer and the Contractor may mutually agree to have the trimming operations performed at an alternate location such as a field laboratory or other similar location. In such cases, the Engineer will take possession of the cores immediately after they are obtained from the roadway and will retain custody of the cores until testing is completed. Either the Department or Contractor representative may perform trimming of the cores. The

Engineer will witness all trimming operations in cases where the Contractor representative performs the trimming operation.

Dry the core holes and tack the sides and bottom immediately after obtaining the cores. Fill the hole with the same type of mixture and properly compact the mixture. Repair core holes with other methods when approved.

2.9.3.3. **Placement Testing.** Perform placement tests in accordance with Table 16. After the Engineer returns the cores, the Contractor may test the cores to verify the Engineer's test results for in-place air voids. The allowable differences between the Contractor's and Engineer's test results are listed in Table 11.

2.9.3.3.1. **In-Place Air Voids.** The Engineer will measure in-place air voids in accordance with [Tex-207-F](#) and [Tex-227-F](#). Before drying to a constant weight, cores may be pre-dried using a CoreDry or similar vacuum device to remove excess moisture. The Engineer will average the values obtained for all sublots in the production lot to determine the theoretical maximum specific gravity. The Engineer will use the average air void content for in-place air voids.

The Engineer will use the vacuum method to seal the core if required by [Tex-207-F](#). The Engineer will use the test results from the unsealed core to determine the placement payment adjustment factor if the sealed core yields a higher specific gravity than the unsealed core. After determining the in-place air void content, the Engineer will return the cores and provide test results to the Contractor.

2.9.3.3.2. **Segregation (Density Profile).** Test for segregation using density profiles in accordance with [Tex-207-F](#), Part V when using a thermal camera instead of the thermal imaging system. Density profiles are not required and are not applicable when using a thermal imaging system. Density profiles are not applicable in areas described in Section 3076.4.9.3.1.4., "Miscellaneous Areas."

Perform a minimum of one density profile per subplot. Perform additional density profiles when any of the following conditions occur, unless otherwise approved:

- the paver stops due to lack of material being delivered to the paving operations and the temperature of the uncompacted mat before the initial break down rolling is less than the temperatures shown in Table 17;
- areas that are identified by either the Contractor or the Engineer with thermal segregation;
- any visibly segregated areas that exist.

Table 17
Minimum Uncompacted Mat Temperature Requiring a Segregation Profile

High-Temperature Binder Grade ¹	Minimum Temperature of the Uncompacted Mat Allowed Before Initial Break Down Rolling ^{2,3,4}
PG 64	<250°F
PG 70	<260°F
PG 76	<270°F

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.
2. Segregation profiles are required in areas with moderate and severe thermal segregation as described in Section 3076.4.7.3.1.3.
3. Minimum uncompacted mat temperature requiring a segregation profile may be reduced 10°F if using a chemical WMA additive as a compaction aid.
4. When using WMA, the minimum uncompacted mat temperature requiring a segregation profile is 215°F.

Provide the Engineer with the density profile of every subplot in the lot within one working day of the completion of each lot. Report the results of each density profile in accordance with Section 3076.4.2., "Reporting and Responsibilities."

The density profile is considered failing if it exceeds the tolerances in Table 18. No production or placement payment adjustments greater than 1.000 will be paid for any subplot that contains a failing density profile. When a hand-held thermal camera is used instead of a thermal imaging system, the Engineer will measure the density profile at least once per project. The Engineer's density profile results will be used when available. The Engineer may require the Contractor to remove and replace the area in question if the area fails the density profile and has surface irregularities as defined in Section 3076.4.9.3.3.5., "Irregularities." The subplot in question may receive a production and placement payment adjustment greater than 1.000, if applicable, when the defective material is successfully removed and replaced.

Investigate density profile failures and take corrective actions during production and placement to eliminate the segregation. Suspend production if 2 consecutive density profiles fail unless otherwise approved. Resume production after the Engineer approves changes to production or placement methods.

Table 18
Segregation (Density Profile) Acceptance Criteria

Mixture Type	Maximum Allowable Density Range (Highest to Lowest)	Maximum Allowable Density Range (Average to Lowest)
Type B	8.0 pcf	5.0 pcf
Type C, Type D & Type F	6.0 pcf	3.0 pcf

2.9.3.3.3. Longitudinal Joint Density.

4.9.3.3.3.1. **Informational Tests.** Perform joint density evaluations while establishing the rolling pattern and verify that the joint density is no more than 3.0 pcf below the density taken at or near the center of the mat. Adjust the rolling pattern, if needed, to achieve the desired joint density. Perform additional joint density evaluations, at least once per subplot, unless otherwise directed.

4.9.3.3.3.2. **Record Tests.** Perform a joint density evaluation for each subplot at each pavement edge that is or will become a longitudinal joint. Joint density evaluations are not applicable in areas described in Section 3076.4.9.3.1.4., "Miscellaneous Areas." Determine the joint density in accordance with [Tex-207-F](#), Part VII. Record the joint density information and submit results on Department forms to the Engineer. The evaluation is considered failing if the joint density is more than 3.0 pcf below the density taken at the core random sample location and the correlated joint density is less than 90.0%. The Engineer will make independent joint density verification at least once per project and may make independent joint density verifications at the random sample locations. The Engineer's joint density test results will be used when available.

Provide the Engineer with the joint density of every subplot in the lot within one working day of the completion of each lot. Report the results of each joint density in accordance with Section 3076.4.2., "Reporting and Responsibilities."

Investigate joint density failures and take corrective actions during production and placement to improve the joint density. Suspend production if the evaluations on two consecutive subplots fail unless otherwise approved. Resume production after the Engineer approves changes to production or placement methods.

2.9.3.3.4. **Recovered Asphalt Dynamic Shear Rheometer (DSR).** The Engineer may take production samples or cores from suspect areas of the project to determine recovered asphalt properties. Asphalt binders with an aging ratio greater than 3.5 do not meet the requirements for recovered asphalt properties and may be deemed defective when tested and evaluated by the Materials and Tests Division. The aging ratio is the DSR value of the extracted binder divided by the DSR value of the original unaged binder. Obtain DSR values in accordance with AASHTO T 315 at the specified high temperature performance grade of the asphalt. The Engineer may require removal and replacement of the defective material at the Contractor's expense. The asphalt binder will be recovered for testing from production samples or cores in accordance with [Tex-211-F](#).

2.9.3.3.5. **Irregularities.** Identify and correct irregularities including segregation, rutting, raveling, flushing, fat spots, mat slippage, irregular color, irregular texture, roller marks, tears, gouges, streaks, uncoated aggregate

particles, or broken aggregate particles. The Engineer may also identify irregularities, and in such cases, the Engineer will promptly notify the Contractor. If the Engineer determines that the irregularity will adversely affect pavement performance, the Engineer may require the Contractor to remove and replace (at the Contractor's expense) areas of the pavement that contain irregularities. The Engineer may also require the Contractor to remove and replace (at the Contractor's expense) areas where the mixture does not bond to the existing pavement.

If irregularities are detected, the Engineer may require the Contractor to immediately suspend operations or may allow the Contractor to continue operations for no more than one day while the Contractor is taking appropriate corrective action.

2.9.4. **Exempt Production.** The Engineer may deem the mixture as exempt production for the following conditions:

- anticipated daily production is less than 500 tons;
- total production for the project is less than 5,000 tons;
- when mutually agreed between the Engineer and the Contractor; or
- when shown on the plans.

For exempt production, the Contractor is relieved of all production and placement sampling and testing requirements, except for coring operations when required by the Engineer. The production and placement pay factors are 1.000 if the specification requirements listed below are met, all other specification requirements are met, and the Engineer performs acceptance tests for production and placement listed in Table 16 when 100 tons or more per day are produced.

- produce, haul, place, and compact the mixture in compliance with the specification and as directed;
- control mixture production to yield a laboratory-molded density that is within $\pm 1.0\%$ of the target laboratory-molded density as tested by the Engineer;
- compact the mixture in accordance with Section 3076.4.8., "Compaction;" and
- when a thermal imaging system is not used, the Engineer may perform segregation (density profiles) and thermal profiles in accordance with the specification.

2.9.5. **Ride Quality.** Measure ride quality in accordance with Item 585, "Ride Quality for Pavement Surfaces," unless otherwise shown on the plans.

5. MEASUREMENT

3.1 **Dense Graded Hot-Mix Asphalt.** Hot mix will be measured by the ton of composite hot-mix, which includes asphalt, aggregate, and additives. Measure the weight on scales in accordance with Item 520, "Weighing and Measuring Equipment."

3.2 **Tack Coat.** Tack coat will be measured at the applied temperature by strapping the tank before and after road application and determining the net volume in gallons from the calibrated distributor. The Engineer will witness all strapping operations for volume determination. All tack, including emulsions, will be measured by the gallon applied.

The Engineer may allow the use of a metering device to determine asphalt volume used and application rate if the device is accurate within 1.5% of the strapped volume.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under Section 3076.5.1, "Measurement," will be paid for at the unit bid price for "Dense Graded Hot-Mix Asphalt" of the mixture type, SAC, and binder specified. These prices are full compensation for surface preparation, materials, placement, equipment, labor, tools, and incidentals.

The work performed and materials furnished in accordance with this Item and measured as provided under Article 3076.5.2, "Measurement," will be paid for at the unit bid price for "Tack Coat" of the tack coat provided. These prices are full compensation for materials, placement, equipment, labor, tools, and incidentals. Payment adjustments will be applied as determined in this Item; however, a payment adjustment factor of 1.000 will be assigned for all placement sublots for "level ups" only when "level up" is listed as part of the item bid description code. A payment adjustment factor of 1.000 will be assigned to all production and placement sublots when "exempt" is listed as part of the item bid description code, and all testing requirements are met.

Payment for each subplot, including applicable payment adjustments greater than 1.000, will only be paid for sublots when the Contractor supplies the Engineer with the required documentation for production and placement QC/QA, thermal profiles, segregation density profiles, and longitudinal joint densities in accordance with Section 3076.4.2., "Reporting and Responsibilities." When a thermal imaging system is used, documentation is not required for thermal profiles or segregation density profiles on individual sublots; however, the thermal imaging system automated reports described in [Tex-244-F](#) are required.

Trial batches will not be paid for unless they are included in pavement work approved by the Department.

Payment adjustment for ride quality will be determined in accordance with Item 585, "Ride Quality for Pavement Surfaces."

3.1

Production Payment Adjustment Factors. The production payment adjustment factor is based on the laboratory-molded density using the Engineer's test results. The bulk specific gravities of the samples from each subplot will be divided by the Engineer's maximum theoretical specific gravity for the subplot. The individual sample densities for the subplot will be averaged to determine the production payment adjustment factor in accordance with Table 19 for each subplot, using the deviation from the target laboratory-molded density defined in Table 9. The production payment adjustment factor for completed lots will be the average of the payment adjustment factors for the four sublots sampled within that lot.

Table 19
Production Payment Adjustment Factors for Laboratory-Molded Density¹

Absolute Deviation from Target Laboratory-Molded Density	Production Payment Adjustment Factor (Target Laboratory-Molded Density)
0.0	1.050
0.1	1.050
0.2	1.050
0.3	1.044
0.4	1.038
0.5	1.031
0.6	1.025
0.7	1.019
0.8	1.013
0.9	1.006
1.0	1.000
1.1	0.965
1.2	0.930
1.3	0.895
1.4	0.860
1.5	0.825
1.6	0.790
1.7	0.755
1.8	0.720
> 1.8	Remove and replace

1. If the Engineer's laboratory-molded density on any subplot is less than 95.0% or greater than 98.0%, take immediate corrective action to bring the mixture within these tolerances. The Engineer may suspend operations if the Contractor's corrective actions do not produce acceptable results. The Engineer will allow production to resume when the proposed corrective action is likely to yield acceptable results.

2.1.1. **Payment for Incomplete Production Lots.** Production payment adjustments for incomplete lots, described under Section 3076.4.9.2.1.1., "Incomplete Production Lots," will be calculated using the average production payment factors from all sublots sampled.

A production payment factor of 1.000 will be assigned to any lot when the random sampling plan did not result in collection of any samples within the first subplot.

2.1.2. **Production Sublots Subject to Removal and Replacement.** If after referee testing, the laboratory-molded density for any subplot results in a "remove and replace" condition as listed in Table 19, the Engineer may require removal and replacement or may allow the subplot to be left in place without payment. The Engineer may also accept the subplot in accordance with Section 3076.5.3.1., "Acceptance of Defective or Unauthorized Work." Replacement material meeting the requirements of this Item will be paid for in accordance with this Section.

3.2 **Placement Payment Adjustment Factors.** The placement payment adjustment factor is based on in-place air voids using the Engineer's test results. The bulk specific gravities of the cores from each subplot will be divided by the Engineer's average maximum theoretical specific gravity for the lot. The individual core densities for the subplot will be averaged to determine the placement payment adjustment factor in accordance with Table 20 for each subplot that requires in-place air void measurement. A placement payment adjustment factor of 1.000 will be assigned to the entire subplot when the random sample location falls in an area designated on the plans as not subject to in-place air void determination. A placement payment adjustment factor of 1.000 will be assigned to quantities placed in areas described in Section 3076.4.9.3.1.4., "Miscellaneous Areas." The placement payment adjustment factor for completed lots will be the average of the placement payment adjustment factors for up to four sublots within that lot.

Table 20
Placement Payment Adjustment Factors for In-Place Air Voids

In-Place Air Voids	Placement Pay Adjustment Factor	In-Place Air Voids	Placement Pay Adjustment Factor
< 2.7	Remove and Replace	6.4	1.042
2.7	0.710	6.5	1.040
2.8	0.740	6.6	1.038
2.9	0.770	6.7	1.036
3.0	0.800	6.8	1.034
3.1	0.830	6.9	1.032
3.2	0.860	7.0	1.030
3.3	0.890	7.1	1.028
3.4	0.920	7.2	1.026
3.5	0.950	7.3	1.024
3.6	0.980	7.4	1.022
3.7	0.998	7.5	1.020
3.8	1.002	7.6	1.018
3.9	1.006	7.7	1.016
4.0	1.010	7.8	1.014
4.1	1.014	7.9	1.012
4.2	1.018	8.0	1.010
4.3	1.022	8.1	1.008
4.4	1.026	8.2	1.006
4.5	1.030	8.3	1.004
4.6	1.034	8.4	1.002
4.7	1.038	8.5	1.000
4.8	1.042	8.6	0.998
4.9	1.046	8.7	0.996
5.0	1.050	8.8	0.994
5.1	1.050	8.9	0.992
5.2	1.050	9.0	0.990
5.3	1.050	9.1	0.960
5.4	1.050	9.2	0.930
5.5	1.050	9.3	0.900
5.6	1.050	9.4	0.870
5.7	1.050	9.5	0.840
5.8	1.050	9.6	0.810
5.9	1.050	9.7	0.780
6.0	1.050	9.8	0.750
6.1	1.048	9.9	0.720
6.2	1.046	> 9.9	Remove and Replace
6.3	1.044		

2.2.1.

Payment for Incomplete Placement Lots. Payment adjustments for incomplete placement lots described under Section 3076.4.9.3.1.2., "Incomplete Placement Lots," will be calculated using the average of the placement payment factors from all sublots sampled and sublots where the random location falls in an area designated on the plans as not eligible for in-place air void determination.

If the random sampling plan results in production samples, but not in placement samples, the random core location and placement adjustment factor for the subplot will be determined by applying the placement random number to the length of the subplot placed.

If the random sampling plan results in placement samples, but not in production samples, no placement adjustment factor will apply for that subplot placed.

A placement payment adjustment factor of 1.000 will be assigned to any lot when the random sampling plan did not result in collection of any production samples.

- 2.2.2. **Placement Sublots Subject to Removal and Replacement.** If after referee testing, the placement payment adjustment factor for any subplot results in a “remove and replace” condition as listed in Table 20, the Engineer will choose the location of two cores to be taken within 3 ft. of the original failing core location. The Contractor will obtain the cores in the presence of the Engineer. The Engineer will take immediate possession of the untrimmed cores and submit the untrimmed cores to the Materials and Tests Division, where they will be trimmed if necessary and tested for bulk specific gravity within 10 working days of receipt.

The bulk specific gravity of the cores from each subplot will be divided by the Engineer's average maximum theoretical specific gravity for the lot. The individual core densities for the subplot will be averaged to determine the new payment adjustment factor of the subplot in question. If the new payment adjustment factor is 0.700 or greater, the new payment adjustment factor will apply to that subplot. If the new payment adjustment factor is less than 0.700, no payment will be made for the subplot. Remove and replace the failing subplot, or the Engineer may allow the subplot to be left in place without payment. The Engineer may also accept the subplot in accordance with Section 3076.5.3.1., “Acceptance of Defective or Unauthorized Work.” Replacement material meeting the requirements of this Item will be paid for in accordance with this Section.

- 3.3 **Total Adjusted Pay Calculation.** Total adjusted pay (TAP) will be based on the applicable payment adjustment factors for production and placement for each lot.

$$TAP = (A+B)/2$$

where:

$A = \text{Bid price} \times \text{production lot quantity} \times \text{average payment adjustment factor for the production lot}$

$B = \text{Bid price} \times \text{placement lot quantity} \times \text{average payment adjustment factor for the placement lot} + (\text{bid price} \times \text{quantity placed in miscellaneous areas} \times 1.000)$

Production lot quantity = Quantity actually placed - quantity left in place without payment

Placement lot quantity = Quantity actually placed - quantity left in place without payment - quantity placed in miscellaneous areas

Special Specification 5008

Precast Concrete Wheel Stops



1. DESCRIPTION

Furnish and install precast concrete wheel stops.

2. MATERIALS

Provide 6 ft. length minimum wheel stops unless otherwise shown on the plans or as approved.

Hydraulic Concrete. Use Class A concrete conforming to Item 421, "Hydraulic Cement Concrete."

Reinforcing Steel. Use reinforcing steel conforming to Item 440, "Reinforcement for Concrete." Minimum reinforcing is two No. 4 or No. 3 bars placed longitudinally.

Precast. Submit commercially available wheel stop designs for approval.

3. CONSTRUCTION

Use an anchoring method and anchor rod type as shown on the plans or as approved.

4. MEASUREMENT

This Item will be measured by each wheel stop.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Precast Concrete Wheel Stops." This price is full compensation for furnishing, preparing, hauling and placing materials, and for labor, tools, equipment, and incidentals.

Special Specification 6001

Portable Changeable Message Sign



1. DESCRIPTION

Furnish, operate, and maintain portable trailer mounted changeable message sign (PCMS) units.

2. MATERIALS

Furnish new or used material in accordance with the requirements of this Item and the details shown on the plans. Provide a self-contained PCMS unit with the following:

- Sign controller
- Changeable Message Sign
- Trailer
- Power source

Paint the exterior surfaces of the power supply housing, supports, trailer, and sign with Federal Orange No. 22246 or Federal Yellow No. 13538 of Federal Standard 595C, except paint the sign face assembly flat black.

- 3.1 **Sign Controller.** Provide a controller with permanent storage of a minimum of 75 pre-programmed messages. Provide an external input device for random programming and storage of a minimum of 75 additional messages. Provide a controller capable of displaying up to 3 messages sequentially. Provide a controller with adjustable display rates. Enclose sign controller equipment in a lockable enclosure.
- 3.2 **Changeable Message Sign.** Provide a sign capable of being elevated to at least 7 ft. above the roadway surface from the bottom of the sign. Provide a sign capable of being rotated 360° and secured against movement in any position.
- Provide a sign with 3 separate lines of text and 8 characters per line minimum. Provide a minimum 18 in. character height. Provide a 5 × 7 character pixel matrix. Provide a message legibility distance of 600 ft. for nighttime conditions and 800 ft. for normal daylight conditions. Provide for manual and automatic dimming light sources.
- The following are descriptions for 3 screen types of PCMS:
- **Character Modular Matrix.** This screen type comprises of character blocks.
 - **Continuous Line Matrix.** This screen type uses proportionally spaced fonts for each line of text.
 - **Full Matrix.** This screen type uses proportionally spaced fonts, varies the height of characters, and displays simple graphics on the entire sign.
- 3.3 **Trailer.** Provide a 2 wheel trailer with square top fenders, 4 leveling jacks, and trailer lights. Do not exceed an overall trailer width of 96 in. Shock mount the electronics and sign assembly.
- 3.4 **Power Source.** Provide a diesel generator, solar powered power source, or both. Provide a backup power source as necessary.
- 3.5 **Cellular Telephone.** When shown on the plans, provide a cellular telephone connection to communicate with the PCMS unit remotely.

3. CONSTRUCTION

Place or relocate PCMS units as shown on the plans or as directed. The plans will show the number of PCMS units needed, for how many days, and for which construction phases.

Maintain the PCMS units in good working condition. Repair damaged or malfunctioning PCMS units as soon as possible. PCMS units will remain the property of the Contractor.

4. MEASUREMENT

This Item will be measured by each PCMS or by the day used. All PCMS units must be set up on a work area and operational before a calendar day can be considered measurable. When measurement by the day is specified, a day will be measured for each PCMS set up and operational on the worksite.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Portable Changeable Message Sign." This price is full compensation for PCMS units; set up; relocating; removing; replacement parts; batteries (when required); fuel, oil, and oil filters (when required); cellular telephone charges (when required); software; and equipment, materials, tools, labor, and incidentals.

Special Specification 6185

Truck Mounted Attenuator (TMA) and Trailer Attenuator (TA)



1. DESCRIPTION

Furnish, operate, maintain and remove upon completion of work, Truck Mounted Attenuator (TMA) or Trailer Attenuator (TA).

2. MATERIALS

Furnish, operate and maintain new or used TMAs or TAs. Assure used attenuators are in good working condition and are approved for use. A list of approved TMA/TA units can be found in the Department's Compliant Work Zone Traffic Control Devices List. The host vehicle for the TMA and TA must weigh a minimum of 19,000 lbs. Host vehicles may be ballasted to achieve the required weight. Any weight added to the host vehicle must be properly attached or contained within it so that it does not present a hazard and that proper energy dissipation occurs if the attenuator is impacted from behind by a large truck. The weight of a TA will not be considered in the weight of the host vehicle but the weight of a TMA may be included in the weight of the host vehicle. Upon request, provide either a manufacturer's curb weight or a certified scales weight ticket to the Engineer.

3. CONSTRUCTION

Place or relocate TMA/TAs as shown on the plans or as directed. The plans will show the number of TMA/TAs needed, for how many days or hours, and for which construction phases.

Maintain the TMA/TAs in good working condition. Replace damaged TMA/TAs as soon as possible.

4. MEASUREMENT

Truck Mounted Attenuator/Trailer Attenuator (Stationary). This Item will be measured by the each or by the day. TMA/TAs must be set up in a work area and operational before a calendar day can be considered measurable. When measurement by the day is specified, a day will be measured for each TMA/TA set up and operational on the worksite.

Truck Mounted Attenuator/Trailer Attenuator (Mobile Operation). This Item will be measured by the hour. The time begins once the TMA/TA is ready for operation at the predetermined site and stops when notified by the Engineer. A minimum of 4 hr. will be paid each day for each operating TMA/TA used in a mobile operation.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Truck Mounted Attenuators/Trailer Attenuators (Stationary)," or "Truck Mounted Attenuators/Trailer Attenuators (Mobile Operation)." This price is full compensation for furnishing TMA/TA: set up; relocating; removing; operating; fuel; and equipment, materials, tools, labor, and incidentals.

Special Specification 6240

Telecommunication System



1. DESCRIPTION

Furnish and install telecommunication systems including directional bores along S. Rice, Westpark Dr., Richmond Ave., Post Oak and the I69 NBFR that will house AT&T Texas, AT&T Legacy, Capital Engineering & Communication (Wavevision), Comcast, Fiberlight, Alpheus, XO Communications, Windstream, Level 3 Telecommunication, MCI, Verizon Business, NextEra Energy/FPL Fibernet, Phonoscope, Zayo, and TxDOT ducts as detailed in the plans. Additionally, furnish and install the facilities required to connect from the existing individual facilities to the new facilities to be installed joint directional bore. Contractors working on the AT&T Texas portion of work must comply with the AT&T guidelines and manual that is referred to as Bellcore Practices.

Definitions.

- 2.1.1. **Conduit.** Pipe used to encase telecommunication facilities such as fiber, cable, and inner duct.
- 2.1.2. **Casing.** Pipe used to protect conduit by fully encasing conduit piping; casing can be also described as the pipe that is used to protect conduit in trenchless construction methods. This refers to the outer pipe. Pipe used to house inner duct is not to be considered as casing.
- 2.1.3. **Conduit Structure (Duct Bank).** Groups of conduit arranged in tiers and encased as specified in the plans.
- 2.1.4. **Contractor.** A contractor that is a telecommunications expert per industry standards and is on the Utility Owners approved list.
- 2.1.5. **Utility Owner.** Any one of the following telecommunication utilities or their respective representatives: AT&T Texas, AT&T Legacy, Capital Engineering & Communication (Wavevision), Comcast, Fiberlight, Level 3 Telecommunication, MCI, Verizon Business, NextEra Energy/FPL Fibernet, Phonoscope, Zayo, and TxDOT.
- 2.1.6. **Joint Directional Bore.** Various bores that encompasses all Utility Owners and TxDOT. Intended to distinguish the facilities that are not wholly owned by any of the Utility Owners but are shared by all Utility Owners and TxDOT. Any other directional bores included in the plans are not intended for joint use by the remaining Utility Owners.

2. MATERIALS

- 2.1. **Telecommunication System.** Supply permanent telecommunication system structure materials such as pipe, innerducts, handholes, manholes, fittings, mule tape, duct terminators and plugs, electronic markers, etc. Obtain approval for any deviations from the following.
 - 2.1.1. **Steel Casing.** Provide Grade B steel pipe manufactured in accordance with ASTM A53. When shown in the plans, supply a 16 in. steel casing with a minimum wall thickness of 0.25 in. When shown in the plans, supply an 18 in. steel casing with a minimum wall thickness of 0.25 in. When shown in the plans, supply a 36 in. steel casing with a minimum wall thickness of 0.375 in. Provide steel casing that complies with "Buy America" standards.
 - 2.1.2. **Conduit.**
 - 2.1.2.1. **Bore-Gard.** Provide conduit for the joint directional bore wherever specified in the plans, that is Schedule 40 Bore-Gard, 4.5 in. O.D., with a minimum wall thickness of 0.50 in.

- 2.1.2.2. **C-PVC.** Provide 4.5 in. O.D. Chlorinated Polyvinyl Chloride (CPVC) Schedule 40 IPS pressure pipe manufactured in accordance with ASTM F441 for installations requiring the use of 4 in. C-PVC.
- 2.1.3. **Inner Duct.**
- 2.1.3.1. **Joint Directional Bore Inner Duct.** Provide an inner duct utilized for the joint directional bore made of high performance polyethylene manufactured in accordance with ASTM F714 and that meets the following minimum criteria per the inner duct assigned in the plans:
- 1.66 in. O.D., SDR 9, minimum wall thickness of 0.184 in.
 - 1.90 in. O.D., SDR 9, minimum wall thickness of 0.211 in.
 - Resin to meet ASTM D3350 cell classification standards for PE445574C and meet 2000 hours of PENT per ASTM F1473-07, extruded in accordance with NSF61.
 - Resin material manufacturing must comply with ASME Code Case N-755 guidelines and meet NSF 14 requirements. Recycled compounds are not allowed unless said compounds are derived from source manufacturer's own plant resin.
 - Use a Service factor of 0.63 to determine the pressure rating.
- Purchase the outer casing material from vendors/manufacturers with a history of supplying ASME Class 3 Critical Service Safety Rated Pressure Pipeline pipe and fittings. Submit manufacturer's Certificate of Conformance to Specifications and documentation of PENT testing to the Engineer for approval before procurement.
- 2.1.3.2. **Outside Joint Directional Bore Limits.** Provide inner duct utilized for the areas outside of the joint directional bore and wherever specified in the plans, that is made of high density polyethylene manufactured in accordance with ASTM D3035 with the following minimum criteria:
- 1.66 in. O.D., SDR 13.5, minimum wall thickness 0.133 in.
 - 1.90 in. O.D., SDR 13.5, minimum wall thickness 0.141 in.
- 2.1.3.3. **Color Coding.** Comply with the color coding for the inner ducts as established in the plans. Uniquely identify by color each Utility Owner and TxDOT inner duct facility. Procure the appropriate quantities of inner duct to ensure respective Utility Owners and TxDOT facilities are restricted to their respective color. The colors for inner duct are limited to the following: blue, orange, yellow, green, brown, red, and white.
- 2.1.4. **Handholes and Manholes.** When the use of handholes and manholes are specified on the plans, provide handholes and manholes that comply with the requirements shown in the plans.
- 2.1.4.1. **Pre-cast Handholes and Manholes.** Pre-cast handholes and manholes will be provided by AT&T Texas.
- 2.1.4.2. **Cast-In-Place Handholes and Manholes.** Materials used for cast-in-place handholes and manholes will conform to Bellcore Practices Section 622-505-210. Use Hydraulic cement with a nominal compressive strength of 4000 psi in conformance with ASTM C150. Provide rebar that are deformed steel bars having a 60,000 psi yield strength conforming to ASTM A615.
- 2.1.5. **Miscellaneous Materials, Tools, and Equipment.** Furnish non-telecommunication system materials, backfill, mortar, tools, supplies, equipment, etc. required to properly complete the work that meets TxDOT and Utility Owners minimum requirements.
- 2.2. **Procurement of Fiber Optic Cables.** The respective Utility Owners will provide the Fiber Optic Cable within the project limits. Contact the Utility Owner Representatives listed in the General Notes, Item 5, "Control of Work," 60 days before the required delivery date.
- 2.3. **Backfill.** Furnish backfill in accordance with Item 400, "Excavation and Backfill for Structures."
- 2.3.1. **Bedding.** Provide bank sand for bedding beginning 2 in. below the bottom of the duct bank and extending to 12 in. above top of the duct bank.

- 2.3.2. **Original Material Backfill (Type A).** Use Type A backfill wherever an excavation is 10 ft. or greater from an existing edge or proposed edge of pavement. Provide material that is equivalent to original material or better, free of debris, and compacted to 90%-95% standard proctor density in 8 in. lifts.
- 2.3.3. **Cement Stabilized Backfill.** Provide cement-stabilized backfill in accordance with Item 400, "Excavation and Backfill for Structures." Use cement-stabilized backfill to fill the trench from top of bedding to bottom of subgrade whenever an excavation is under or within 10 ft. of a roadway.
- 2.4. **Concrete Encasement.** Provide concrete encasement material in accordance with Item 421, "Hydraulic Cement Concrete," Class A.
- 2.5. **Miscellaneous Other Material.** Assume responsibility for providing other customary material not listed in the plans or within this specification to properly complete the project including, but not limited to, the following:
- Fencing, permanent or temporary,
 - Resin, fusing materials, and equipment,
 - Sand bags and silt fencing,
 - Drilling fluids,
 - Water to conduct bore procedure,
 - Contractor's temporary buildings and latrines,
 - Timbers or other materials, and
 - Steel mandrel.
- 2.6. **Defective or Damaged Material.** Inspect materials for defects before lowering them into the trench. Repair or replace as directed any defective, damaged, or unsound material. Should damaged materials be placed, furnish at no expense to the Department labor and materials required for removing and replacing the defective material. Should the Contractor damage the materials after installation, the Engineer may permit the damaged section to be cut from the length, unless it is the opinion of the Engineer that the entire length was damaged. The cost and replacement of broken materials is at the expense of the Contractor.

3. CONSTRUCTION

- 3.1. **Contractor.** Construction including, but not limited to, excavations, installations, mandrelling, proving, and boring operations must be performed by a Department approved Contractor. The AT&T Texas Subcontractor that installs the underground telephone system must be an approved AT&T Texas Contractor in good standing with AT&T Texas. Table 1 below lists vendors that satisfy this requirement at the time this specification was printed; however, verify with AT&T Texas before finalizing the subcontract for AT&T Texas work, obtain a current listing of approved contractors. Other qualified Contractors not included in the list are allowed, if approved by AT&T Texas.

Table1
Approved Contractors

Contractor	Contact	Address	Phone
Team Fishel	Mike Wood	14806 Eastex Freeway, Humble, TX 77396	281-802-6552
Future Telecom	Eddie Beltran	1800 Bruton Rd., Balch Springs, TX 75180	281-435-1689
Mastec North America, Inc.	James Polask	PO Box 2770149, Atlanta, GA 30384	512-751-3868

- 3.2. **As-Built Documentation.** Notify CobbFendley (Carlos Armenta office (713) 462-3242; fax (713) 462-3262, cell (713) 304-3616), 10 days before the start of construction, 3 days before de-mobilizing, and 2 days before re-mobilizing, as applicable. Allow CobbFendley access to the site to observe construction and survey as-built facilities.

If unable to keep the trench open for the as-built verification, indicate the installed top of duct depth and edges of the duct bank(s) by means of a temporary above ground appurtenance such as a stake. In such cases, note and make available to CobbFendley the number of ducts in the duct bank and the depths of the ducts.

- 3.3. **Trench Excavation.** Perform trench excavation in accordance with Item 400, "Excavation and Backfill for Structures," as outlined herein, as shown on the plans, and as directed.
- 3.3.1. **Trenches for Conduit and Conduit Structures.**
 - 3.3.1.1. **Width of Trenches.** Construct trenches that are adequate to accommodate working room needed to place conduit. When placing unencased conduit, allow 2 in. on each side of the duct structure for backfill. When placing encased conduit, allow 1-1/2 in. on each side of the structure for concrete. When shoring or sheeting is used, measure the trench width from the inside surfaces of the uprights or sheeting.
 - 3.3.1.2. **Depth of Trench.** Minimum trench depth is the height of the duct structure plus 24 in. This height includes any top protection when the trench is in an area under live load or traffic.
- 3.3.2. **Handhole and Manhole Excavations.** The width and depth of excavation for handholes and manholes will be determined by the lines and grades as established in the plans, dimensions of the handholes and manholes, and as directed.
- 3.3.3. **Excavation Below Grade.** Correct any part of the bottom of the trench excavated below the limits specified in Section 3.3.1.2., "Depth of Trench" with approved material and compacted in a manner as described in Article 400.3 of Item 400, "Excavation and Backfill for Structures" and as directed.
- 3.3.4. **Trenching at Driveways.** Except where otherwise noted, maintain access to driveways at all times. A flotation ditch must be installed across a driveway wherever noted on the plans, as directed and when necessary to facilitate the movement of traffic. Be responsible for the means, methods, and equipment utilized to construct the flotation ditch.
- 3.4. **Backfill.** Provide backfill and perform backfill operations in accordance with Item 400, "Excavation and Backfill for Structures," as described herein and as directed.
- 3.5. **Pavement.** Remove pavement and surfaces as part of the trench excavation in accordance with Item 400, "Excavation and Backfill for Structures." The removal and restoration of pavement and surfaces will be based upon the minimum trench width as described in Section 3.3.1.2. plus 2 in. on each side of the trench.
- 3.6. **Boring.** Install casing pipe and conduit by bore in conformance with Item 476, "Jacking, Boring, or Tunneling Pipe or Box." Install bore spacer in accordance with the manufacturer's guidelines.
- 3.6.1. **Directional Boring.** Install casing pipe and conduit by horizontal directional drill in conformance with the North American Society of Trenchless Technology (NASTT), "Mini-Horizontal Directional Drilling Manual" (1995) or ASTM F 1962 "Standard Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit under Obstacles including River Crossings."
- 3.7. **Handholes and Manholes.** Handholes and manholes will be of the size and type as shown on the plans. Set manholes to the lines and grades as shown on the plans. Manholes will have a minimum 60 in. cover from finished grade to the top of the manhole box unless specified otherwise in the plans or as directed by AT&T Texas. Place handholes in line with final grade except where noted otherwise in the plans or as directed by AT&T Texas.
- 3.7.1. **Pre-cast Handholes and Manholes.** Install pre-cast handholes and manholes according to Bellcore Practices Section 622-506-200, "Precast Concrete Manholes, 38Y Types, Installation."
- 3.7.2. **Cast-In-Place Handholes and Manholes.** Construct cast-in-place materials in accordance with Bellcore Practices Section 622-505-210, "Concrete Manholes, Cast-In-Place Construction."
- 3.8. **Manholes.** Install manholes in accordance with the plans. Notify the appropriate contact person a minimum 10 days before placing manholes in order to ensure compliance with this requirement.

- 3.9. **Removing Existing Facilities.** Remove abandoned telephone facilities, including manholes and conduit in accordance with Item 496, "Removing Structures." Remove conduit as necessary for the installation of the new facility and for the connectivity between existing and new facilities, after an AT&T Texas approved contractor has removed the existing cables. An AT&T Texas approved contractor is not required to perform any other AT&T Texas removals once the existing facility is abandoned in place.
- 3.10. **Proofing and Mandrilling.** After the duct has been installed, pass a mandrel through the duct in the presence of the Engineer and after observing the 10 day notification to Utility Owners. If the mandrel fails to pass through the duct being tested, either the duct is obstructed, misaligned, or the curve has too small a radius. Correct defective ducts. After the duct(s) are repaired, repeat the mandrel test in that section of duct. Mandrels are constructed in various sizes, depending upon the use and nature of the section being tested (e.g., duct size). The OD of a test mandrel is normally 80% of the ID of nominal size of the duct. The length of the mandrel will vary depending upon the manufacturer and mandrel type (testing conduit or removing debris).
- 3.11. **Protective Concrete Cap.** Construct concrete caps above conduit structures as detailed in the plans in conformance with Item 421, "Hydraulic Cement Concrete."

4. MEASUREMENT

- 4.1. **Joint Directional Bore.** This item will be measured by the foot of the type and size shown on the plans for "Directional Bore (Comm)." This is a plans quantity measurement item. The quantity to be paid is the quantity shown in the proposal, unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.
- 4.2. **Conventional Bore.** This item will be measured by foot of the type and size shown on the plans for "Conventional Bore (Comm)." Steel casings will not be measured directly but are subsidiary to the conventional bore installation. This is a plans quantity measurement item. The quantity to be paid is the quantity shown in the proposal, unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.
- 4.3. **Proofing.** This item will not be measured directly for payment but is subsidiary to the item being proofed.
- 4.4. **Trench Excavation and Backfill.** This item is measured by the foot as shown on the plans for "Trench (Comm)." Bends and appurtenances for conduit will not be measured for payment but are subsidiary to the duct bank measurement. This is a plans quantity measurement item. The quantity to be paid is the quantity shown in the proposal, unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.
- 4.5. **Pavement.** Cutting and restoring pavement will not be measured directly but is subsidiary to the structure installed in the trench.
- 4.6. **Handholes.** Handholes will be measured by each handhole installed, complete in place for "Handhole (Comm)." Necks and covers will not be measured for payment, but are incidental to the item installed. Handholes installed over existing telecommunication facilities will be measured for payment as described herewith. Any adjustment or removal of the existing structures necessary for the placement of the proposed handhole(s) will not be measured directly, but is incidental to the item installed.
- 4.7. **Manholes.** Manholes will be measured by each manhole installed, complete in place for "Manhole (Comm)." Necks and covers will not be measured for payment, are incidental to the item installed. Manholes installed over existing telecommunication facilities will be measured for payment as described herewith. Any adjustment or removal of the existing structures necessary for the placement of the proposed manhole(s) will not be measured directly, but is incidental to the item installed.
- 4.8. **Conduit.** Conduit will be measured by the foot as shown on the plans of the type and size specified within the trench or bore for "Conduit (Comm)." This is a plans quantity measurement item. The quantity to be paid

is the quantity shown in the proposal, unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

- 4.9. **Innerduct.** This item will be measured by the foot for "Innerduct (Comm)" of the type and size specified on the plans within the trench or bore. This is a plans quantity measurement item. The quantity to be paid is the quantity shown in the proposal, unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.
- 4.10. **Casing.** Casing will be measured by the foot for "Casing (Comm)" of the type and size specified on the plans. This is a plans quantity measurement item limited to casing utilized in directional bore. The quantity to be paid is the quantity shown in the proposal, unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required. Casing used for conventional bores will not be measured directly but is subsidiary to the bore.
- 4.11. **Protective Concrete Cap.** This item will not be measured for payment, but is subsidiary to the structure installed.
- 4.12. **Concrete Removal and Restoration.** This item will not be measured for payment, but is subsidiary to the structures installed.
- 4.13. **Remove Existing Facilities.**
- 4.13.1. **Conduit.** Removal of existing conduit as indicated on the plans will be measured by the foot for "Remove (Comm)." This is a plans quantity measurement item. The quantity to be paid is the quantity shown in the proposal, unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.
- 4.13.2. **Handhole and Manholes.** Handholes or manholes removed will be measured by each removed item as shown on the plans for "Remove Structure (Comm)." This is a plans quantity measurement item. The quantity to be paid is the quantity shown in the proposal, unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.
- 4.13.3. **Poles.** Existing poles removed will be measured by each item specified for removal on the plans for "Remove Structure (Comm)". This is a plans quantity measurement item. The quantity shown in the proposal, unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantity are required.

5. PAYMENT

- 5.1. **Joint Directional Bore.** The work performed and materials furnished in accordance with this item and measured as provided under "Measurement" will be paid for at the unit price for "Directional Bore (Comm)" of the length specified on the plans. This price is full compensation for installing outer casing, conduit and innerduct, mobilization, pilot hole, fusing materials, drilling fluid, sand bags, silt fencing; and for labor, tools, equipment, and incidentals.
- 5.2. **Conventional Bore.** The work performed and materials furnished in accordance with this item and measured as provided under "Measurement" will be paid at the unit price of "Conventional Bore (Comm)" of the length specified on the plans. This price is full compensation for installing outer casing, conduit and innerduct, mobilization, pilot hole, fusing materials, drilling fluid, sand bags, silt fencing; and for labor, tools, equipment, and incidentals.
- 5.3. **Proofing.** Proofing will not be paid for directly but will be subsidiary to the pipe installed.
- 5.4. **Trench Excavation and Backfill.** The work performed and materials furnished in accordance with this item and measured as provided under "Measurement" will be paid for at the unit price for "Trench (Comm)." This

price is full compensation for installing conduit and inner duct; excavating, furnishing and placing backfill, replacing pavement structure, sod, riprap, curbs, or other surface; for furnishing and installing fittings, bends, adaptors, lubrication access fittings, expansion joints, concrete, and underground mylar conduit marking tape; and for labor, tools, equipment, and incidentals.

- 5.5. **Pavement.** Pavement will not be paid for directly but will be subsidiary to the pipe installed.
- 5.6. **Handholes.** The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price for "Handhole (Comm)" of the size specified on the plans complete in place. This price is full compensation for bonding, rings, frames, covers, and joint sealing compound as detailed on the plans.
- 5.7. **Manholes.** The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price for "Manhole (Comm)" of the size specified on the plans complete in place. This price is full compensation for bonding, rings, frames, covers, and joint sealing compound as detailed on the plans.
- 5.8. **Conduit.** The work performed in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price for "Conduit (Comm)" of the size and type specified on the plans. This price is full compensation for only the material cost; construction costs associated with the installation of this item are considered incidental to the trench or bore in which they are installed.
- 5.9. **Innerduct.** The work performed in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price for "Innerduct (Comm)" of the size and type specified on the plans. This price is full compensation for only the material cost; construction costs associated with the installation of this item are considered incidental to the trench or bore in which they are installed.
- 5.10. **Casing.** The work performed in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price for "Casing (Comm)" of the size and type specified on the plans. This price is full compensation for only the material cost; construction costs associated with the installation of this item are considered incidental to the trench or directional bore in which they are installed. Casing material utilized for conventional bores will not be paid for directly, but will be considered incidental to the conventional bore installed.
- 5.11. **Protective Concrete Cap.** This item will not be paid for directly but will be subsidiary to the structures installed.
- 5.12. **Concrete Removal and Restoration.** This item will not be paid for directly but will be subsidiary to the pipe installed.
- 5.13. **Remove Existing Facilities.**
 - 5.13.1. **Conduit.** The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price for "Remove (Comm)." This price is full compensation for removal and disposal of existing facilities as shown on the plans.
 - 5.13.2. **Handhole and Manholes.** The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price for "Remove Structure (Comm)." This price is full compensation for removal and disposal of existing facilities as shown on the plans.
 - 5.13.3. **Poles.** The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price for "Remove Structure (Comm)." This price is full compensation for removal and disposal of existing facilities as shown on the plans. Other above ground appurtenances will be subsidiary to the conduit removal.

Special Specification 7017

Sanitary Sewers



1. DESCRIPTION

Furnish labor, materials, and equipment necessary to provide a complete sanitary sewer system in accordance and compliance with ANSI, AWWA, ASTM, ASA, SSPC, ACI, and NSF standards, the plans and specifications, and in compliance with the Department's Utility Accommodation Policy (Title 43. T.A.C., Sections 21.31-21.55).

The abbreviations ANSI, AWWA, ASTM, ASA, SSPC, ACI, and NSF in this specification refer to the following organizations:

■ ANSI	American National Standards Institute
■ AWWA	American Water Works Association
■ ASTM	American Society for Testing and Materials
■ ASA	American Standards Association
■ SSPC	Steel Structures Painting Council
■ ACI	American Concrete Institute
■ NSF	National Sanitation Foundation

When referring to the specifications of the above organizations, it means the latest standard or tentative standard in effect on the date of the proposal.

The size and location of utility lines shown on the plans were obtained from field surveys and from the various utility companies. The Department does not assume responsibility for the accuracy of the information presented, nor does it warrant that every utility line is shown.

2. MATERIALS

Furnish new and unused materials for this project unless otherwise specified on the plans. Provide a manufacturer's certificate of compliance for quality control of materials unless otherwise shown on the plans, except for the inspection requirements of Item 464, "Reinforced Concrete Pipe."

- 2.1 **Circular Concrete Pipe.** Provide circular concrete pipe 36 in. in diameter and greater conforming to the class specified on the plans and in accordance with Item 464, "Reinforced Concrete Pipe." Circular concrete pipe less than 36 in. in diameter is not allowed. Furnish polyvinyl chloride (PVC)-lined concrete pipe interiors for corrosion protection. See Section 2.9., "Plastic Liner for Concrete Pipes," of this specification.

Upon delivery to the trenches, the pipe and specials will be inspected for transportation and handling damages incurred after acceptance at the source of manufacture. Repair the pipe if necessary. If, in the opinion of the Engineer, the repairs are sound, properly finished and cured, and the repaired pipe conforms to the requirements of these specifications, it will be acceptable.

Unless otherwise specified on the plans, for concrete pipe, use corrosion-resistant rubber gasket joints of the "push on" type, and that meet the requirements of ASTM C443.

- 2.2. **Polyvinyl Chloride (PVC) Pipe and Fittings.**

For PVC pipe, use steel casing meeting the requirements of Section 2.8, "Steel Casing Pipe," of this specification.

Use lubricant for assembly that has no detrimental effects to the gasket or pipe and is of the type recommended by the pipe manufacturer.

Furnish a manufacturer's certification that the pipe and fittings being furnished on the project meet the requirements of this specification. Ensure written approval from the Engineer in charge accompanies this certification to the project site, before installing the pipe and fittings.

Provide pipe and fittings that are free from defects which, in the judgment of the Engineer, would hinder their ability to function as planned.

- 2.2.1. **Gravity Sewer.** Provide plastic pipe and fittings meeting the requirements of ASTM D3034 SDR35, D2241 or D3034 SDR26, F679 SDR35, or F794 steel Carrier Pipe.
- 2.2.2. **Force Mains.** Provide PVC pipe for force mains meeting or exceeding the requirements of AWWA C-900/905. Use ductile-iron (Class 52) fittings for force main pipes.
- 2.2.3. **Water Main Crossings.** If constructing gravity or force main sewers in the vicinity of water mains, meet the requirements of the "Rules and Regulations for Public Water Systems" adopted in 1992 by the Texas Water Commission (now the Texas Commission on Environmental Quality).
- 2.3. **Ductile-Iron Pipe and Fittings.** Provide ductile-iron pipe that meets the requirements of ANSI A21.51 (AWWA C151) Class 53. Unless otherwise specified on the plans, determine the pipe thickness based on the depth of cover and an internal pressure of 150 psi. Furnish pipe in nominal 18 ft. or 20 ft. lengths.

Provide fittings for use with ductile-iron pipe that meet the requirements of ANSI Standard A21.10 (AWWA C110). Design the fittings for a minimum working pressure of 150 psi.

Provide joints for ductile-iron pipe of the type in accordance with the requirements of ANSI Standard A21.11 (AWWA C151) for push on or ANSI A21.15 for flanged end.
- 2.4. **Line Interiors.** Provide lined interiors meeting ANSI A21.4, cement lined with seal coat or ANSI A 21.16 fusion bonded epoxy coating for interior. Comply with NSF 61.
- 2.5. **Sanitary Sewer and Force Main Interiors**
 - 2.5.1. **Preparation.** Provide commercial blast cleaning conforming to SSPC-SP6.
 - 2.5.2. **Liner Thickness.** Provide a nominal liner thickness of 40 mils for the pipe barrel interior and a minimum of 6 to 10 mils at the gasket groove and outside spigot end to 6 in. back from the end.
 - 2.5.3. **Testing.** Perform testing in accordance with ASTM G 62, Method B for voids and holidays. Provide written certification.
 - 2.5.4. **Acceptable Lining Materials.** Provide approved virgin polyethylene conforming to ASTM D 1248, with inert fillers and carbon black to resist ultraviolet degradation during storage, heat bonded to the interior surface of pipe and fittings.
 - 2.5.4.1. **Ceramic Epoxy Protection.** For the exterior of sanitary sewers, furnish a prime coat and outside asphaltic coating conforming to ANSI A21.10, ANSI A21.15, or ANSI A21.51 for pipe and fittings in open cut excavation and in casings.
- 2.6. **Gaskets.** Furnish, when no contaminant is identified, plain rubber (SBR) gasket material in accordance with ANSI A21.11 or ASTM F 477 (one bolt only). For flanged joints, furnish a 1/8-in.-thick gasket in accordance with ANSI A 21.15.

2.7

Fiberglass Pipe and Fittings. Provide centrifugally cast fiberglass pipe in accordance with the requirements of ASTM D3262 and ASTM D3681. Ensure the actual outside diameter of the pipe is in accordance with Table 3 of ASTM D3754. The standard pipe length is approximately 20 ft. A maximum of 10% of the lengths, excluding special order pipes, may be supplied in random lengths.

Ensure the manufacturer uses only polyester resin systems with a proven history of performance in this particular application. Use only the historical data collected from applications of a composite material of similar construction and composition as the proposed product.

For the reinforcing glass fibers used to manufacture the components, use the highest quality commercial grade glass filaments with binder and sizing compatible with impregnating resins.

Silica sand or other suitable materials may be used for fillers.

If resin additives, such as pigments, dyes, and other coloring agents are used, ensure they are not detrimental to the performance of the pipe and they do not impair visual inspection of the finished product.

Provide gaskets supplied by approved gasket manufacturers, in accordance with ASTM 477, and that are suitable for the service intended.

Provide flanges, elbows, reducers, tees, and other fittings capable of withstanding operating conditions when installed. They may be contact-molded or manufactured from metered sections of pipe joined by glass fiber reinforced overlays.

Use a stiffness class of centrifugally cast fiberglass pipe that satisfies design requirements under ASTM D3262, but that is not less than 46 psi when used in direct-bury operation or 36 psi when installed in a tunnel liner.

Provide centrifugally cast fiberglass pipe with an internal liner resin suitable for service as sewer pipe and that is highly resistant to exposure to sulfuric acid in accordance with ASTM D3681.

Supply pipe manufactured by the centrifugal casting process. An acceptable manufacturer is Hobas Pipe, USA, Inc. or approved equal.

Provide a manufacturer's certification that the pipe and fittings furnished on the project meet the requirements of this specification. Written approval from the Engineer in charge must accompany this certification to the project site, before installing the pipe and fittings.

Furnish pipe and fittings that are free from defects which, in the judgment of the Engineer, would hinder their ability to function as planned.

2.8

Steel Casing Pipe. Provide minimum wall thicknesses in accordance with those shown in Table 1 for HS-20 live loads and depths of bury of up to 16 ft.

Supply the pipe in double random lengths, of at least 16 ft. and at most 40 ft., unless otherwise shown on the plans. Bevel the ends of the pipe for field butt welding. Provide welder qualification in accordance with AWWA C206.

Table 1
Casing Pipe

Casing Pipe Size (in.)	Outside Diameter (in.)	Min. Wall Thickness (in.)	Approx. Weight Uncoated (lb./ft.)
6	6.625	0.219	14.97
8	8.625	0.219	19.64
10	10.750	0.219	24.60
12	12.750	0.219	29.28
14	14.000	0.219	32.00
16	16.000	0.219	36.86
20	20.000	0.250	52.73
24	24.000	0.250	63.41
30	30.000	0.250	79.43
36	36.000	0.250	95.45
42	42.000	0.250	111.50

Note: It is the design Engineer's responsibility to review the design for conditions more extreme than those indicated by this specification and to design accordingly. Do not use a thickness of the pipe wall less than that defined in Table 1.

Furnish steel casing pipe coated with coal-tar enamel externally and with polyamide epoxy internally.

2.9

Plastic Liner for Concrete Pipes. Furnish plastic liner sheets, joint, corner, and weld strips, manufactured from a high molecular weight thermoplastic polymer compounded to make a permanently flexible material suitable for use as a protective liner in pipe or other structures. Ensure polyvinyl chloride resin constitutes a minimum of 99% by weight of the resin used in the formulation. Co-polymer resins are not permitted.

Any time during the manufacture or before the final acceptance of the work, the Engineer may sample specimens taken from sheets, strips, or welded joints for testing.

Changes in formulation will be permitted only after notifying the Engineer and after the manufacturer demonstrates that the new plastic liner meets or exceeds requirements for chemical resistance and physical properties.

Furnish the plastic liner as manufactured by Ameron T-Lok, Poly-Tee, Inc., or approved equal.

Provide plastic liner sheets including locking extensions, joints, corners, and welding strips, which are free of cracks, cleavages, or other defects adversely affecting the protective characteristics of the material.

Except at shop welds, ensure plastic liner sheets, joint, corner, and weld strips have the properties shown in Table 2 when tested at 77°F ± 5°F.

Table 2
Chemical Resistance Test

Property	Initial Result	After Exposure for 112 Days in Chemical Solutions
Tensile Strength, Min.	2200 psi	2100 psi
Elongation at Break, Min.	200%	200%
Shore Diameter, Type D	Within 1 sec. 50-60	±5 (With respect to initial test result)
	10 sec. 35-50	±5
Weight Change	--	± 1.5%

2.10

Liner for Ductile-Iron Pipe. Furnish pipe internally lined with ceramic epoxy Protecto 401 or virgin polyethylene in accordance with the requirements of ASTM D1248, compounded with inert fillers and carbon black to resist ultraviolet light degradation during storage.

Heat-bond the liner to the interior of the pipe and fittings over a blast cleaned surface as recommended by the manufacturer or SSPC-SP6.

Provide a nominal liner thickness of 40 to 50 mils with a minimum thickness of 35 mils and covering surfaces exposed to sanitary sewage.

Test for voids and holidays in accordance with ASTM G62, Method B and provide a manufacturer's certification.

Furnish Polyline liner pipe manufactured by U.S. Pipe and Foundry Company, Polybond by American Cast Iron Pipe Company, or an approved equal.

Apply a polyamide epoxy prime coat to the exterior and ensure the outside asphaltic coating is in accordance with ANSI A21.10, ANSI A21.15, ANSI A21.51, or AWWA C-218 for pipe and fittings in open cut excavation and in casings.

Use a polyurethane coating for the exterior conforming to the requirements of the approved manufacturer, CORROPIPE II – TX, Madison Chemical Industries, Inc., for polyurethane coatings on steel or ductile-iron pipe.

2.11 **Polyethylene Film Wrap.**

2.11.1 **General.** Except where noted on the plans, use polyethylene film or tape as a wrap to protect ductile-iron pipe and fittings only in open ditch placements. Use polyethylene film conforming to the requirements of this specification.

2.11.2 **Film.** For polyethylene film, use virgin polyethylene in accordance with ASTM D1248 and AWWA C105, Type I, Class C, Category 5, Grade E-5, 2.5 to 3.0% carbon black content. Unless otherwise specified on the plans, use film 8 mils thick and with a tensile strength of 1200 to 2500 psi with elongation up to 600%. Also, ensure the dielectric strength is 800 volts per mil of thickness. Furnish the film in either in tubular form or in sheet form. Furnish film supplied in tubular form in the minimum widths shown in Table 3.

Table 3
Minimum Width of Film Tube (when laying flat)

Nominal Pipe Size (in.)	Push-On Joint Flat Tube Width (in.)
4	20
6	20
8	24
10	27
12	30
14	34
16	37
18	41
20	45
24	54

Furnish film supplied in sheet form in a width equal to twice that shown for tube widths.

2.11.3 **Polyethylene Tape.** For the tape used to tape film edges and overlaps, use a 3-in. wide plastic backed adhesive tape. Use Paleocene No. 900, Scotch Wrap No. 50, or approved equal.

2.12 **Concrete.** Unless otherwise shown on the plans, for concrete other than materials for pipe, use Class "A" concrete in accordance with the materials requirements of Item 420, "Concrete Substructures," and Item 421, "Hydraulic Cement Concrete."

2.13 **Cement Stabilized Sand.** Use cement stabilized sand backfill containing a minimum of 7% cement, per cubic yard of material, based on the dry weight of the aggregate in accordance with Test Method TEX-120-E, of material as placed. The materials consist of aggregate, hydraulic cement, and water. Use cement and water in accordance with the materials requirements of Item 421, "Hydraulic Cement Concrete." Furnish

sand, free from deleterious matter, with a maximum Plasticity Index of 6 when tested by Test Method TEX-106-E.

- 2.14 **Backfill and Bedding Materials.** Unless otherwise specified on the plans, furnish sand for bedding of the sanitary sewer that is free from clay lumps, organic material, and other deleterious substances. Use sand that, when tested in accordance with Test Method TEX-106-E, has a maximum Plasticity Index of 7, a maximum Liquid Limit of 25, and for which a maximum of 40% passes the No. 200 sieve.
- Use earth or native soil backfill consisting of soil containing no deleterious material such as trash, wood fragments, organics, or other objectionable material. Furnish the material from either the material removed from the excavation or offsite sources. The material may consist of soil classified by the Unified Soil Classification System (USCS) as CH, CL, SC, SP, SM, SW, or GC. Use earth backfill meeting the compaction requirements of this specification and which does not cause any settlement.
- 2.15 **Manholes.** Use materials for manholes in accordance with the materials requirements of Item 465, "Junction Boxes, Manholes and Inlets" and as shown on the plans, except that brick is not allowed. Use fiberglass manholes if shown on the plans.
- If specified, furnish prefabricated fiberglass manholes conforming to the shape, size, dimension, and details shown on the plans. Unless otherwise shown on the plans, use manhole sections in accordance with ASTM D3753. Acceptable manufacturers: fiberglass manholes manufactured by Containment Solutions Inc., L.F. Manufacturing, Inc., or an approved equal.
- Stencil the date of manufacture and name or trademark of the manufacturer in 1-in. high letters on the inside of the barrel.
- Unless a larger size is specified, use a 48-in. diameter barrel for fiberglass manholes. Construct wall sections of the appropriate thickness for the depth of manhole as specified in ASTM D3753, but not less than 0.48 in. thick.
- Provide a fabricated reducer, bonded at the factory to form a single continuous unit at the top of the manhole barrel to accept concrete grade rings and cast-iron frame and cover. For the reducer, use an acceptable design with enough strength to safely support HS-20 loading.
- For the manhole base, use a minimum 12-in. (under the invert) precast concrete base. For precast manhole bases, use an approved steel reinforced design with enough strength to withstand the imposed loads. Include an acceptable joint in the base to receive a fiberglass pipe section forming the barrel of the manhole. Coat precast concrete base sections with Thane Coat TC300 or approved equal, as recommended by the manufacturer.
- 2.16 **Rings and Covers.** Use materials for rings and covers in accordance with the material requirements of Item 471, "Frames, Grates, Rings, and Covers." Use covers and rings conforming to the shapes and dimensions shown on the plans and marked with the wording and logos shown on the plans.
- 2.17 **Reinforcing Steel.** Furnish and place reinforcing steel in accordance with the material requirements of Item 440, "Reinforcement for Concrete."
- 2.18 **Mortar.** Furnish mortar composed of one part cement, two parts finely graded clean sand, and enough water to make the mixture plastic. When required by the Engineer, add a latex adhesive to the mortar. Use latex adhesive in accordance with the requirements of Departmental Material Specifications DMS-8110. Hydrated lime ASTM C207, Type S or lime putty may be added to the mix up to a maximum of 10% by weight of the total dry mix.
- 2.19 **Adjusting Manholes.** Furnish materials for adjusting manholes in accordance with the materials requirements of Item 479, "Adjusting Manholes and Inlets," and as shown on the plans.

- 2.20 **Nonmetallic Pipe Detection.** If installing nonmetallic pipe longitudinally underground, a method of detecting the location of the nonmetallic pipe is required. The specific method used is shown on the plans or as approved. This system may involve installing some components in the trench around the pipe which are detectable by a metal detector. Alternately, the system may involve some locating equipment capable of creating a non-destructive pressure wave which can be detected above ground using a portable detection device with both audible and visual indicators. Ensure either system of detection is capable of accurately locating to a maximum depth of 3 ft. over the areas shown on the plans.
- Ensure the selected system is capable of locating lines under earth, concrete, and asphalt surfaces. Use equipment, materials, and installation as specified by the manufacturer.
- 2.21 **Air Release and Vacuum Relief Valves.** Provide combination air valves designed to fulfill the functions of air release, permitting escape of air accumulated in the line at high points of elevation while the line is under pressure and vacuum relief. Paint the valve exterior with an epoxy shop-applied primer.
- 2.21.1 **Air Release Valves.** Provide air release valves in combination with inlet, outlet connections, and orifice as specified on the plans. For valve materials, use: ASTM 48, Class 30, cast iron; float and leverage mechanism with body and cover, ASTM A 240 or ASTM A 276 stainless steel; orifice and seat, stainless steel against Buna-N or Viton mechanically retained with hex head nut and bolt. For other valve internals, use stainless steel or bronze.
- 2.21.2 **Air Release and Vacuum Valves.** Provide single-body standard combination or duplex-body custom combination valves as shown on the plans.
- 2.21.2.1 **2-in. and 3-in. Single-Body Valves.** Provide inlet and outlet sizes as shown on the plans and an orifice sized for a 100 psi working pressure. Valve materials: for the body, cover, and baffle, use ASTM A48, Class 35, or ASTM A126, Grade B cast iron; for the plug or poppet, use ASTM A276 stainless steel; for the float, use ASTM A240 stainless steel; for the seat, use Buna-N; and for other valve internals, use stainless steel.
- 2.21.2.2 **3-in. and Larger Duplex-Body Valves.** Provide air release valves as shown on the plans. Valve materials: for the body and cover, use ASTM A48, Class 35, cast iron; for the float, use ASTM A240 stainless steel; for the seat, use Type-304, stainless steel and Buna-N; and for other valve internals, use stainless steel or bronze. Construct air release valves as specified in Section 2.21.1, "Air Release Valves."
- 2.21.3 **Vacuum Release Valves.** Provide air inlet vacuum relief valves with flanged inlets and outlet connections as shown on the plans. Valve materials: for the valve body, use ASTM B 584 bronze, copper alloy 836; for the spring, use ASTM A 313, Type 304, stainless steel; for the bushing, use ASTM B 584 bronze, copper alloy 932; for the retaining screw, use ASTM A 276, Type 304, stainless steel. Set the valves to open under a pressure differential of 0.25 psi (maximum).

3. CONSTRUCTION

- 3.1 **Excavating and Backfilling.** Excavate and backfill as required to complete the work as outlined in this specification, in accordance with construction requirements of Item 400, "Excavation and Backfill for Structures," and as shown on the plans.
- Construct sewer lines in open cut trenches with vertical sides, except in those locations where the pipe is to be jacked, bored, tunneled, or augered. Construct the trench in accordance with the dimensions shown in the Excavation and Backfill Diagram.
- Sheath and brace trenches to the extent necessary to maintain the sides of the trench in a vertical position throughout the construction period. Protect excavation greater than 5 ft. in depth as required in accordance with Item 402, "Trench Excavation Protection" or Item 403, "Temporary Special Shoring."
- Always open and excavate the trench to the finished grade for a minimum distance of 50 ft. in advance of the previously placed joint of pipe. To allow for possible adjustment of alignment and grade, positively locate

existing sewer lines which will connect to the sewer under construction, well in advance of making those connections.

Construct sanitary sewers in dry trenches. Perform additional work as necessary, such as dewatering or well-pointing, placing additional sheathing, or placing a concrete seal in the bottom of the trench, to accomplish this objective. This work, if necessary, is subsidiary to the pertinent bid items.

If it is necessary to excavate trenches adjacent to improved property, take precautions necessary to prevent damaging or impairing that property. If it is necessary to disturb grass, shrubs, driveways, etc., restore such improvements to their original condition.

3.1.1 **Existing Streets.** Unless otherwise shown on the plans, open cut existing streets.

If sanitary sewer construction requires cutting through existing streets outside the limits of new street construction, replace them in kind in conformance with the pertinent specifications in the proposal and as directed.

Cut-back the existing pavement a minimum of 1 ft. on each side of the sanitary sewer trench before replacing concrete and asphalt paving. Additional trench width may be required for unstable conditions. If this repaired area is to remain after final construction, then the repair area is to be full lane width from expansion joint to expansion joint for concrete pavement or the length of the repair for asphalt pavement.

If, in the opinion of the Engineer, a single lane closure is insufficient to maintain traffic across a trench, construct temporary access as necessary to safely maintain the traffic flow.

If the proposed sanitary sewer parallels the edge of an existing permanent pavement (i.e., concrete pavement, concrete base with asphalt surface, etc.) and is 3 ft. or less from the edge of that pavement, protect the trench with timber sheathing and bracing. Leave the bracing in place at intervals of 5 ft. maximum, for the duration of the excavation.

Keep the street surface adjacent to the trench free of surplus spoil. Place construction materials at locations that will minimize interference with the traveling public.

A maximum of 2 street intersections may be closed at any time, unless otherwise authorized by the Engineer in writing.

3.1.2 **Cutting and Restoring Pavement.** If installing sewers in streets or other paved areas, the work includes saw cutting the pavement and asphalt stabilized base (if any), removing the foundation base to neat lines, and replacing these materials after sewer excavation and backfill are complete. The type and thickness of replacement materials is shown on the plans. Performing work on or making repairs to damaged base and pavement within the project limits will be measured and paid for under the applicable specifications.

If excavating in streets or highways, maintain traffic and provide traffic control in accordance with the plans.

When allowed by the construction sequence shown on the plans or when directed, use a "temporary concrete cap" of the depth and class of concrete shown on the plans, or as otherwise directed, instead of a permanent repair.

3.2 **Bedding.** Before laying the pipe, shape the bedding material to conform to the outside diameter of the pipe as shown on the plans. Carefully prepare bell holes to fit the bell where using bell and spigot pipe.

3.3 **Laying Pipe.**

3.3.1 **General.** Lay sewers in a straight line, so that a light can be seen from one manhole to the other, even for the smaller size sewers. Accurately lay the pipe to line and grade, with the spigot end downstream entering the bell of the next joint of pipe. Fit pipes and fittings together and match them so they form a sewer with a

smooth, watertight, and uniform invert. Take measures to provide uniform bearing for the entire length of the pipe.

Install sewer lines meeting the minimum separation distance from any potable water line, as required by the Design Criteria for Sewage Systems, Texas Administrative Code - Chapter 317.13, Appendix E., of the Texas Commission on Environmental Quality Regulations.

Lay pipe to the lines and grades shown on the plans. To ensure proper placement, use adequate surveying methods, equipment, and employ personnel competent in the use of this equipment. Unless otherwise approved, the maximum allowable deviation of the pipe from the horizontal and vertical alignment indicated on the plans is 0.10 ft. Measure and record the "as-built" horizontal alignment and vertical grade at a maximum of every 50 ft. on the on-site recorded plans.

Submit a mylar set of plans with this "as-built" information to the Engineer for final acceptance.

During pipe laying operations, always keep pipe trenches free of water which might impair pipe laying operations. Ensure holes for bells are of ample size to prevent bells from contacting the subgrade. Carefully grade the pipe trenches to provide uniform support along the bottom of the pipe.

Do not lay more than 50 ft. of pipe in the trench ahead of backfilling operations. If the pipe laying operations are interrupted for more than 48 hours, cover the pipe laid in the trench simultaneously on each side of the pipe to avoid lateral displacement of the pipe and damage to the joints. If adjustment of the position of a length of pipe is required after it has been laid, remove and re-lay it in accordance with these specifications at no expense to the Department. After completing pipe laying and joining operations, clean the inside of the pipe and remove any debris.

Use caution to prevent damage to the coating or polyethylene film wrap when placing backfill. Place backfill in accordance with this specification.

Do not place more than 1,000 ft. of pipe on publicly used streets ahead of the trench excavating machine. Obtain permission, in writing, from the owner or the owner's agent before placing materials or equipment on private property.

Regardless of the type of pipe being used, place sand bedding in the bottom of the trench and compact it to a depth of 6 in. Carefully grade the bedding and excavate bell holes.

Lay pipe with bell ends facing in the direction of laying, unless otherwise directed.

Adjust the pipe and fittings to be at their proper locations and prepare each joint as specified on the plans and by the Engineer. While laying each joint of pipe in the trench, center the spigot end in the bell of the previously laid pipe. Force the pipe home and bring it to correct line and grade. Ensure each length of pipe rests on the bottom of the trench throughout its entire length.

If laying of pipe is discontinued for the day or for an indefinite period, tightly place a cap or plug in the end of the last pipe laid to prevent the intrusion of water. When water is excluded from the interior of polyvinyl chloride pipe, place enough backfill on the pipe to prevent floating. Schedule the work to prevent the possibility of floatation. Remove pipe that has floated from the trench and re-lay it as directed.

When PVC pipe is assembled on top of the trench, allow it to cool to ground temperature before backfilling to prevent pull out due to thermal contraction.

3.3.2

PVC Pipe and Fittings. Splicing is not allowed unless the required length of a straight section of pipe exceeds 30 ft. The Engineer may waive this requirement to meet special conditions.

Use devices required for attaching the pipe to portions of structures or to other types of pipe that are shown on the plans or as approved. Install a water stop gasket and clamp at each PVC connection to a manhole.

After installing, clean and paint pipe and fittings which are exposed to view in the completed structure, as shown on the plans.

- 3.3.3 **Ductile-Iron Pipe and Fittings.** Provide and operate proper and suitable tools and appliances for safely and conveniently handling the pipe and fittings. Use caution to prevent damaging the pipe coating. Examine pipe for defects and do not lay pipe that is known to be defective. If any defective pipe is discovered after being laid, remove and replace it with sound pipe at no expense to the Department. If the pipe requires cutting, perform it in conformance with the manufacturer's recommendations for pipe 12 in. in diameter and smaller. Use approved cutting methods for larger pipes. Ensure each cut is smooth and at right angles to the axis of the pipe.

- 3.3.4 **Thrust Restraint.** Unless otherwise shown on the plans, provide Portland cement concrete thrust blocking for force mains up to 12-in. in diameter, to prevent movement of buried lines under pressure at bends, tees, caps, valves, and hydrants. Place concrete in accordance with details on the plans. Place thrust blocks between undisturbed ground and fittings. Anchor the fittings to the thrust blocks so that the pipe and fitting joints are accessible for repairs. Extend the concrete from 6 in. below the pipe or fitting to 12 in. above.

For force mains larger than 12 in. in diameter, and where indicated on the plans, provide restrained joints conforming to the requirements of the force main pipe material specifications. Install restrained joints for the length of pipe on both sides of each bend or fitting for the full length shown on the plans.

Horizontal and vertical bends between zero and 10 degrees deflection angle will not require thrust blocks or harnessed or restrained joints.

For horizontal and vertical bends between 10 degrees and 90 degrees deflection angle, provide thrust restraint as shown on the plans.

Provide thrust restraint at tees, plugs, blowoff drains, valves, and caps, as indicated.

Reinforced concrete encasement of force main pipe and fittings may be used in lieu of manufactured joint restraint systems. Provide alternate joint restraint systems using reinforced concrete encasement that conform to following design requirements:

- Ensure design calculations are performed and sealed by Professional Engineer licensed in the State of Texas.
- Base design calculations upon soil parameters qualified in a geotechnical report for the site where alternative thrust system will be installed. When data is not available for the site, use parameters recommended by a geotechnical engineer.
- The design system pressure is the specified test pressure.
- Utilize the following safety factors in sizing the restraint system:
 - Apply a factor of safety equal to 1.5 for passive soil resistance.
 - Apply a factor of safety equal to 2.0 for soil friction.
- Contain the encasement entirely within the standard trench width and terminate it on both ends at the pipe bell or coupling.
- Design the concrete encasement reinforcement steel for all loads, including internal pressure and longitudinal forces. Design the concrete in accordance with ACI 318.

Install piping and fittings true to alignment with rigid support. Provide anchorage where required. Repair any damage to linings before the pipe is installed. Clean out each length of pipe before installation. Adhere to the pipe manufacturer's recommendations.

Ensure the deflection at joints does not exceed that recommended by the pipe manufacturer. Provide fittings, in addition to those shown on the plans, if required, in areas where conflict exists with existing facilities.

Fabricate flanged joints using gaskets, bolts, bolt studs with a nut on each end, or studs with nuts where the flange is tapped. Use the number and size of bolts that conform to the same ANSI standard as the flanges.

Tighten bolts in flanged joints or mechanical joints alternately and evenly.

- 3.3.5 **Fiberglass Pipe.** Do not use stiffening ribs or rings. Provide a water stop flange (wall pipe) for connection to existing cast-in-place manholes.

If the pipe is cut in the field or the interior lining is disturbed, re-coat the interior with a similar quantity of the liner resin in accordance with this specification.

Do not exceed forces recommended by the manufacturer for coupling pipes. If excessive force is required, remove the coupling, determine the source of the problem and correct it.

When jointing the pipe, do not exceed the deflection angle, measured by mandrel, permitted by the manufacturer, unless otherwise directed.

Either affix gaskets to the pipe by means of a suitable adhesive or install them in such a manner to prevent the gasket from rolling out of the pipe's pre-cut groove.

- 3.4 **Manholes.** Construct manholes in accordance with Item 465, "Junction Boxes, Manholes and Inlets" and with the details shown on the plans.

- 3.5 **Adjusting Manholes.** Adjust manholes in accordance with the construction requirements of Item 479, "Adjusting Manholes and Inlets" and as shown on the plans.

Elevations of manholes may be raised by using precast concrete rings. Elevations of manholes may be lowered by removing existing cast-in-place walls, adjusting rings, or the top section of the barrel below the new elevation and then rebuilding or raising the elevation to the proper height.

Salvage and reuse cast-iron frames and covers. Protect or block off manhole or inlet bottoms by using wood forms shaped to fit so that no debris or soil falls to the bottom during adjustment.

Install a cast-in-place slab at the top of the manhole barrel to receive the cast-iron frame and cover. Form concrete slabs a minimum of 6 in. thick. Set the cast-iron frame for the manhole cover in a full mortar bed and adjust it to the established elevation. If placing in streets, adjust covers to be flush with the top of the pavement.

The following requirements apply for fiberglass manhole adjustments: install concrete grade rings for height adjustment, as required. Construct the chimney on the flat shoulder. Do not load the manhole except on the load bearing shoulder of the manhole. The maximum adjustment height is 18 in.

Use a cut length of approved Fiberglass Reinforced Pipe (FRP) to create a finished liner inside the adjustment rings. Cut the pipe to fit between the casting and the top of the fiberglass manhole reducer. Completely seal the liner pipe to the casting and to the manhole reducer section with sealant as recommended by the manufacturer.

Set the cast-iron frame on top of the cone or adjustment rings using approved sealant materials and adjust the elevation of the casting cover to match the pavement surface. For manholes in unpaved areas, set the top of the frame a minimum of 6 in. above the existing ground line unless otherwise shown on the plans.

- 3.6 **Service Connections.** If existing service connections are tied into existing sewers which will be abandoned, reconnect such connections to the proposed sewers as shown on the plans or as directed.

If sewers are more than 6 ft. in depth from the finished grade to the top of the pipe, construct service connections by placing stacks on the sewer line.

Construct sewer stacks in a manner approved by the Engineer and in accordance with the details shown on the plans. If stacks are to be adjusted, make the adjustment in a manner as directed by the Engineer.

If sewers are 6 ft. or less in depth from the finished grade to the top of the pipe, construct service connections by placing wyes or tees in the sewer line at each location and using 1/4 or 1/8 bends where necessary to tie into the existing house sewer lead.

For stub outs, use PVC sewer pipe, 6-in. through 10-in. diameters, in accordance with ASTM D1784 and ASTM 3034 with a cell classification of 12454-B. Use a SDR (ratio of diameter to wall thickness) of 26 for pipe 12-in. in diameter or less and a SDR of 35 for larger pipe.

Use gasket-jointed PVC pipe with the gasket in accordance with ASTM D3212.

Select the service connection pipe diameter to match the existing service diameter, but use a minimum diameter of 6-in.

Furnish a one-piece prefabricated saddle, made either of polyethylene or PVC, with a neoprene gasket for connection to HDPE. Use full body fittings for new PVC installation.

For connection between a stub out and existing service, use a minimum 6-in. diameter flexible PVC coupling, Fernco Adapter, or an approved equal as needed.

Use 1/2-in. stainless steel bands to secure saddles to the liner pipe and the couplings to the service line.

Reconnect service connections, including those to unoccupied or abandoned buildings or to vacant lots, unless otherwise directed.

Include reconnected services on the as-built plans. Record the exact distance from each service connection to the nearest downstream manhole.

Test the service connection before backfilling. Use backfill in accordance with this specification and details as shown on the plans.

3.7 **Jacking, Boring, or Tunneling Pipe.**

3.7.1 **General.** Perform jacking, boring, or tunneling for sanitary sewers at the locations shown on the plans and at other locations specifically designated.

Unless otherwise shown on the plans, provide casing pipe in accordance with the requirements of Section 2.8., "Steel Casing Pipe," of this specification.

3.7.2 **Jacking.** Perform jacking in accordance with the requirements of Section 476.3.1., "Jacking," of Item 476, "Jacking, Boring, or Tunneling Pipe or Box."

3.7.3 **Boring.** Perform boring in accordance with the requirements of Section 476.3.2., "Boring or Tunneling," of Item 476, "Jacking, Boring, or Tunneling Pipe or Box."

If sewer lines cross underneath driveways (16 ft. wide or less) and sidewalks, install pipe in tight-fitting augered holes.

If the centerline of the proposed sanitary sewer is 10 ft. or less from the centerline of an 8-in. diameter or larger growing tree, place the pipe in a tight-fitting augered hole. Extend the bored hole at least 4 ft. beyond each side of the tree.

3.7.4 **Tunneling.** Perform tunneling in accordance with the requirements of Section 476.3.3., "Tunneling," of Item 476, "Jacking, Boring, or Tunneling Pipe or Box."

3.8 **Handling of Pipe and Accessories.**

- 3.8.1 **General.** Unload pipe, fittings, and accessories at the point of delivery and haul them to the project site. Distribute the material opposite or near to the place where it will be laid in the trench. Do not drop the materials. Do not skid or roll pipe handled on skid ways against pipe already on the ground.

Load, transport, unload, and otherwise handle pipe and fittings in a manner and by methods which will prevent damage to them. Handle and transport pipe with equipment designed, constructed, and arranged to prevent damage to the pipe, lining, and coating. Bare chains, hooks, metal bars, or narrow skids or cradles are not permitted to come in contact with the coatings. Ensure spiders are installed by the manufacturer at joint ends of fittings.

Hoist pipe from the trench side into the trench by using a sling of smooth steel cable, canvas, leather, nylon, or similar material.

During pipe construction operations, always use caution to prevent injury to the pipe, protective linings, and coatings.

If stacking pipe, package it on timbers. Place protective pads under the banding straps at the time of packaging.

If fork trucks are used to relocate pipe, pad the forks using carpet or some other suitable type of material. When relocating pipe using a crane or backhoe, use nylon straps, not chains or cables around the pipe for lifting.

Do not lift pipe using hooks at each end of the pipe.

Repair or replace any damage done to the pipe or the protective lining and coating, from any cause, during the installation of the pipeline and before final acceptance by the purchaser, at the expense of the laying Contractor, and in conformance with the applicable standards and as directed.

- 3.8.2 **Cleaning of Pipe and Accessories.** Remove lumps, blisters, and excess coating from the bell and spigot ends of ductile-iron pipe and fittings. Wire brush the outside of the spigot and the inside of the bell and wipe clean, dry, and free from oil and grease before laying the pipe.

Remove foreign matter or dirt from the interior of sanitary sewer pipe and accessories and from the mating surfaces of the joints before lowering the material into the trench. During and after laying by approved means, keep the pipe and accessories clean.

Use cleaning solutions, detergents, solvents, etc. with caution when cleaning PVC pipe.

- 3.9 **Abandoning Sanitary Sewers.** Where plans call for abandoning sanitary sewers, adhere to the following general procedure:

After the replacement main is constructed, tested, and released, and after services are transferred to the replacement line, locate the line to be abandoned and trace it back to the feeder line and at this point cut, plug, and abandon it. Grout the pipe if required by the plans.

- 3.10 **Removing Sanitary Sewers, Casing, Force Main, and Manholes.** Remove sanitary sewers, casing, force mains, and manholes in accordance with Item 100, "Preparing Right of Way" or as shown on the plans. This work includes removing and disposing of the pipe and appurtenances as shown on the plans or as directed. Excavation and backfill, as required, are subsidiary to this Item.

- 3.11 **Joining Pipe and Accessories.**

- 3.11.1 **General.** After thoroughly cleaning the inside of the bell and the outside of the spigot, install members in conformance with the manufacturer's recommendation.
- Mark pipe and accessories that are not furnished with a depth mark before assembling to assure that the spigot end is inserted to the full depth of the joint.
- 3.11.2 **Polyvinyl Chloride Pipe and Accessories.** Join plastic pipe in conformance with the instructions furnished by the manufacturer. Do not handle or install pipe joined using solvent cementing techniques, in the trench until after the joints are sufficiently "cured" to prevent weakening the joint.
- Use lubrication for rubber-jacketed joints that is water soluble, non-toxic, non-supporting of bacteria growth, and has no deteriorating effect on PVC or the rubber gaskets.
- 3.11.3 **Ductile-Iron Pipe.** Except as noted on the plans, wrap ductile-iron pipe (including fittings and other appurtenances) with a polyethylene film wrap material.
- 3.11.4 **Fiberglass Pipe.** Unless otherwise shown on the plans, field connect pipe with fiberglass sleeve couplings that use elastomeric sealing gaskets as the sole means to maintain joint water tightness. Ensure the joints meet the performance requirements of ASTM D4161.
- 3.11.5 **Diversion Pumping.** Provide continuous sanitary sewer service to users of the sewer system during construction and maintenance operations, by diverting the flow around such areas. Maintain sewer flow to prevent backup or overflow onto streets, yards, and unpaved areas or into buildings, adjacent ditches, storm sewers, and waterways. Do not divert sewage outside of the sanitary sewer system. During pump operation, provide an experienced operator on site to monitor operation, adjust pumps, perform minor repairs to the system, and report problems.
- 3.12 **Installing the Nonmetallic Pipe Detection System.** Install the nonmetallic pipe detection system concurrently with placing the proposed pipe. Install this system as specified by the manufacturer and as approved. Install a complete, operational system that is satisfactory to the owner of the utility.
- 3.13 **Air Release and Vacuum Valves.** Inspect valves in open and closed positions to verify they are in satisfactory working condition. Install valves in conformance with the manufacturer's recommendation. Set manholes and vaults plumb as shown on the details and center manholes on valves. Provide above-ground vents for manholes and vaults as shown on the plans.

4. TESTING SANITARY SEWERS FOR LEAKAGE

- 4.1 **Basic Requirements.** Ensure sewers, when tested in accordance with this specification, do not show leakage of more than 50 gallons per 24 hours per inch of inside diameter, per mile of sewer.
- 4.2 **General.** Conduct testing under the supervision of the Engineer. It is the Engineer's option to conduct tests by either the infiltration method or the exfiltration method. On sewers larger than 24 in. in diameter, the tests may consist of visual inspection inside the sewer to locate leaks. The visual inspection method will be used for monolithic sewers. Where the section of sewer to be tested is entirely below the ground water table that will provide the required test head, the test will ordinarily be made by the infiltration method.
- Test the first section of each size or type of sewer laid on the job that is 300 ft. or greater in length, installed by each crew, to determine the adequacy of the materials and methods used and the proficiency of the crew. Backfill this section to a minimum of 18 in. above the top of the pipe and test it without undue delay. If this initial section fails to meet the requirements of the test, make changes in methods, materials, and crew as necessary to correct the deficiency. It is the Engineer's option to require the Contractor to test any or all of the remaining sections of the sewer.
- Completely backfill sewers, other than the first section described above, except at the stacks, before testing. It is the Contractor's option to make preliminary tests with a minimum of 18 in. of backfill over the pipe to

determine if any need for repairs in the sewer is indicated. Such preliminary tests are entirely for the Contractor's information and will not be accepted instead of final tests.

Unless notified that the test will be made by the infiltration method, leave the tops of the stacks exposed and unplugged until after performing the leak test. Temporarily extend upward, stacks which may terminate below the test level by installing an additional length of pipe in the top.

Notify the Engineer a minimum of 24 hours in advance of performing the tests.

If the bottom of the trench is below the ground water level, provide suitable means at each manhole for readily determining the ground water level until testing is completed or waived by the Engineer. This may, as an example, consist of a pipe not less than 3 in. in diameter, plugged at the bottom and perforated for at least the lower 3 ft., with the perforations wrapped with at least two thicknesses of burlap, set in the trench before backfilling. Remove such pipes or cut them off at least 2 ft. below the ground after testing is completed or waived by the Engineer. Before removing, protect the pipes against damage and exclude earth or other material from them.

It is the Engineer's option, to vary the procedures described below under "infiltration test" and "exfiltration test" provided the methods used give an accurate measurement of the leakage occurring at the water levels specified.

4.3 **Testing Procedures (Gravity System).**

4.3.1 **Infiltration Test.** This test may be used where the ground water level rises to a plane that provides a test head not less than that specified for exfiltration tests. Stop all pumps and allow the ground water to return to its normal level (at least the elevation as indicated above) and allow it to remain so for at least 24 hours (the pipe will be filled with water to the overflow depth) and ensure leakage flows at a uniform rate through the opening in the plug in the downstream end of the section of sewer being tested before starting the test. Determine leakage by measuring the flow through the opening in the downstream plug during a given time. Perform 5 separate measurements over a 2-hour period. Use the average of the measurements, discarding any 1 of the 5 measurements, except the last, that varies by more than 50% from the average of the other 4. If the results of the test are otherwise satisfactory, but the last of the 5 measurements shows leakage in excess of that permitted, continue the tests to determine if additional leaks have developed during testing.

4.3.2 **Exfiltration Test.** It is the Contractor's option to keep the pipe full of water for 24 hours before the test to permit absorption by the pipe. If the Contractor wishes to fill the pipe, notify the Engineer by the time backfill is completed. The Engineer will then give notice at least 48 hours before the test will be made to allow time for filling and soaking the pipe.

Supply plugs for this purpose. At least 2 hours before the test starts, bleed off the water to below the level of the top of the pipe at its lower end and allow it to remain so until the water level remains static at this level or continues to fall. Perform the test in the following manner:

Insert a watertight plug equipped with a pipe riser and brace it in the inlet opening of the downstream manhole. Insert and brace a similar plug, equipped with a suitable vent pipe that will permit the air to escape in the pipe at its upper end, in the outlet opening of the upstream manhole.

Fill the sewer and risers with water up to a level that is either 2-1/2 ft. above the highest point in the sewer pipe, service connection, or groundwater table, whichever is highest, plus the vertical distance from the invert of the sewer at its lower end up to the level of the ground water, where such ground water exists above the invert of the sewer.

Fill the sewer with water as a continuous operation as rapidly as the supply will permit. Complete this filling in a minimum of 2 hours for sewers 12 in. in diameter or smaller, 3 hours for sewers 15 in. through 24 in. in diameter, and 4 hours for larger sewers. Over a one-hour period, measure the leakage during the test period by adding measured quantities of water to maintain the water level in the test structure. The quantity of water added to maintain the initial water level is the amount of leakage.

Test criteria and allowable leakage for exfiltration and infiltration tests are shown in Table 5.

Table 5
Test Criteria Table for Exfiltration and Infiltration Water Tests

Diameter of Riser or Stack ¹	Volume per Inch of Depth		Allowable Leakage ²	
	(cu. in.)	(gal.)	Pipe Diameter (in.)	Gallons/Minute Per 100 ft.
1	0.7854	0.0034	6	0.0039
2	3.1416	0.0136	8	0.0053
2.5	4.9087	0.0212	10	0.0066
3	7.0686	0.0306	12	0.0079
4	12.5664	0.0306	15	0.0099
5	19.6350	0.0544	18	0.0118
6	28.2743	0.1224	21	0.0138
8	50.2655	0.2176	24	0.0158
			27	0.0177
			30	0.0197
			36	0.0237
			42	0.0276
1. For other diameters, multiply the square of diameter, by the value for 1 in. diameter.			2. Equivalent to 50 gallons per inch of inside diameter per mile in 24 hours.	

4.3.3

Low Pressure Air Test. For sanitary sewers of less than 36-in. average inside diameters, conduct testing in sections less than 300 ft. long. For shorter runs, conduct the low pressure air test from manhole to manhole. Test 36-in. and larger sewer mains, every two runs of pipe with one pipe joint connection in between.

Perform the low pressure air test in accordance with ASTM C828 and ASTM C924, using holding times not less than those listed in Tables 6, 7, and 8.

Low Pressure Air Test:

Note 1: Tables are based on the following equation:



$$T = 0.0850(D)(K)/(Q)$$

- T = Time for pressure to drop 1.0 pound per square inch gauge (psig), in seconds
- K = $0.000419(D)(L)$, but not less than 1.0
- D = Average inside diameter, in inches
- L = Length of line of the same pipe size being tested, in feet
- Q = Rate of loss = 0.0015 Cubic feet/min./sq. ft. of internal surface area

Note 2: Add 1.0 psig for each 2.3 ft. of water above the highest point in the sewer.

Note 3: When two sizes of pipe are involved, compute the time by using the ratio of the lengths involved. For example, using 400 ft. of 10-in. pipe and 200 ft. of 6-in. pipe:

$$\begin{aligned} \text{Time} &= \frac{\text{Length}_1 \times \text{Time}_1 + \text{Length}_2 \times \text{Time}_2}{\text{Length}_1 + \text{Length}_2} \\ &= \frac{400 \times 15:50 + 200 \times 5:40}{400 + 200} = \frac{400 \times 950 + 200 \times 340}{400 + 200} \\ &= 747 \text{ Seconds} = 12:27 \text{ min:sec} \end{aligned}$$

Acceptance Testing for Sanitary Sewers

Table 6
Time Allowed for Pressure Loss from 3.5 psig to 2.5 psig

Pipe Diameter (in.)	Minimum Time (min:sec)	Length for Minimum Time (ft.)	Time for Longer Length (sec.)	Specification Time for Length (L) Shown in (min:sec)				
				100 ft.	150 ft.	200 ft.	250 ft.	300 ft.
6	5:40	398	0.8548	5:40	5:40	5:40	5:40	5:40
8	7:33	298	1.5196	7:33	7:33	7:33	7:33	7:36
10	9:27	239	2.3743	9:27	9:27	9:27	9:54	11:52
12	11:20	199	3.4190	11:20	11:20	11:20	14:15	17:06
15	14:10	159	5.3423	14:10	14:10	17:48	22:16	26:43
18	17:00	133	7.6928	17:00	19:14	25:39	32:03	38:28
21	19:50	114	10.4708	19:50	26:11	34:54	43:38	52:21
24	22:40	99	13.6762	22:48	34:11	45:35	56:59	68:23
27	25:30	88	17.3089	28:51	43:16	57:42	72:07	68:33
30	28:20	80	21.3690	35:37	53:25	71:14	89:02	106:51
33	31:10	72	25.8565	43:06	64:38	86:11	107:44	129:17

Table 7
Time Allowed for Pressure Loss from 3.5 psig to 2.5 psig

Pipe Diameter (in.)	Minimum Time (min:sec)	Length for Minimum Time (ft.)	Time for Longer Length (sec.)	Specification Time for Length (L) Shown in (min:sec)			
				350 ft.	400 ft.	450 ft.	500 ft.
6	5:40	398	0.8548	5:40	5:42	6:25	7:07
8	7:33	298	1.5196	8:52	10:08	11:24	12:40
10	9:27	239	2.3743	13:51	15:50	17:48	19:47
12	11:20	199	3.4190	19:57	22:48	25:39	28:30
15	14:10	159	5.3423	31:10	35:37	40:04	44:31
18	17:00	133	7.6928	44:52	51:17	57:42	64:06
21	19:50	114	10.4708	61:05	69:48	78:32	87:15
24	22:40	99	13.6762	79:47	91:10	102:34	113:58
27	25:30	88	17.3089	100:58	115:24	129:49	144:14
30	28:20	80	21.3690	124:39	142:28	160:16	178:05
33	31:10	72	25.8565	150:50	172:23	193:55	215:28

Table 8
Time Allowed for Pressure Loss from 3.5 psig to 2.5 psig

Pipe Diameter (in.)	Minimum Time (min:sec)	Length for Minimum Time (ft.)	Time for Longer Length (sec.)	Specification Time for Length (L) Shown in (min:sec)	
				550 ft.	600 ft.
6	5:40	398	0.8548	7:50	8:33
8	7:33	298	1.5196	13:56	15:12
10	9:27	239	2.3743	21:46	23:45
12	11:20	199	3.4190	31:20	34:11
15	14:10	159	5.3423	48:58	53:25
18	17:00	133	7.6928	70:31	76:56
21	19:50	114	10.4708	95:59	104:42
24	22:40	99	13.6762	125:22	136:46
27	25:30	88	17.3089	158:40	173:05
30	28:20	80	21.3690	195:53	213:41
33	31:10	72	25.8565	237:01	258:34

- 4.3.4 **Leakage Testing for Manholes.** After completing manhole construction, wall sealing, or rehabilitation, but before backfilling, test manholes for water tightness using hydrostatic or vacuum testing procedures as described below.

Plug influent and effluent lines, including service lines, with suitably-sized pneumatic or mechanical plugs. Use plugs that are properly rated for the pressures required for the test. Adhere to the manufacturer's safety and installation recommendations. Place plugs a minimum of 6 in. outside of manhole walls. Brace the inverts to prevent lines from dislodging if lines entering the manhole have not been backfilled.

- 4.3.4.1 **Vacuum Testing.** Install the vacuum tester head assembly at the top access point of the manhole and adjust it for a proper seal on the straight top section of the manhole structure. Following the manufacturer's instructions and safety precautions, inflate the sealing element to the recommended maximum inflation pressure. Do not over-inflate the sealing element.

Evacuate the manhole with a vacuum pump to 10 in. of mercury (Hg) then disconnect the pump and monitor the vacuum for the time period specified in the Table 9.

Table 9
Vacuum Test Time Table

Depth in Feet	Time in Seconds, by Pipe Diameter		
	48 in.	60 in.	72 in.
4	10	13	16
8	20	26	32
12	30	39	48
16	40	52	64
20	50	65	80
24	60	78	96
See Note	5.0	6.5	8.0
Note: Add T times for each additional 2-ft. depth. (The values listed above have been extrapolated from ASTM C924-85)			

If the drop in vacuum exceeds 1 in. of mercury (Hg) over the specified time period tabulated above, locate the leaks, complete repairs necessary to seal the manhole, and repeat the test procedure until satisfactory results are obtained.

- 4.3.4.2 **Hydrostatic Exfiltration Testing.** Perform hydrostatic exfiltration testing as follows: seal the wastewater lines entering the manhole with an internal pipe plug, then fill the manhole with water, and maintain it full for a minimum of one hour. The maximum leakage allowed for hydrostatic testing is 0.025 gallons per foot diameter per foot of manhole depth per hour.

If the water loss exceeds the amount tabulated above, locate the leaks, complete repairs necessary to seal the manhole, and repeat the test procedure until satisfactory results are obtained.

- 4.4 **Testing Procedures (Pressure or Force Main System).** After each section of force main is completed and can be isolated so high pressure cannot force test water into the operating system, hydrostatically test it. Perform such testing in accordance with Section 4 of AWWA C-600-77, as modified below:

- First, flush the test section with open bleeds with the flow controlled at the feed from the operating system so that the flushing pressure is always well below that of the operating system.
- Momentarily pressurize the pipe to 160 psi as a "burst" test. Conduct the leak test at a pressure of 140 psi.
- Pipe installations exceeding the leakage determined by the following formula will not be accepted:

$$L = \frac{(S) (D) (P)^{0.5}}{133,200}$$

in which (L) is the allowable leakage, in gallons per hour; (S) is the length of pipe in feet; (D) is the nominal inside diameter of the pipe in inches; and (P) is the average test pressure during the leakage test, in pounds per square inch gauge.



- After removing temporary inserts installed for hydrostatic testing, and before backfilling, leave the replacement piping exposed for visual inspection for leakage under normal pressure (after disinfection).

- 4.5 **Deflection Test of Thermoplastic Pipe (PVC, etc.).** Thirty days after backfilling, test flexible pipe (PVC, etc.) lines for deflection by pulling a mandrel or an approved deflectometer through the line. Perform mandrel testing in accordance with ASTM D3034 or F794. Remove and reinstall sections indicating 5% deflection or more, then retest for leakage and deflection. Mandrel testing is not required for stubs.
- 4.6 **Defective Sewers.** Remove sections of the sewer that show leakage exceeding that which is permitted by these specifications and re-lay them or otherwise make good by repairing using approved methods and materials. Perform permanent type repairs. Repair individual leaks that may appear whether or not the overall section meets the leakage requirements. Individual leaks will ordinarily be revealed by looking through the sewer with a light when the ground water level is over the sewer, or immediately after water from exfiltration tests is emptied from the sewer. Settlement in the backfill during exfiltration tests will be taken as an indication of leakage in the sewer.
- 4.7 **Retests.** After completing repairs, retest for leakage those sewers which failed to meet the requirements of the leak test.
- 4.8 **Responsibility of the Department.** The Engineer will observe the sanitary sewer construction and other contributing work. He or she will monitor the testing of this system for compliance with the plans and specifications.
- 4.9 **Responsibilities of the Contractor.** Conduct tests and supply labor, materials, and equipment required to perform the tests described in this specification.

5. MEASUREMENT

This Item will be measured as follows:

- 5.1 **Sanitary Sewers** will be measured by the foot, of the various sizes, types, and wall thickness (if applicable), of sanitary sewer specified, complete in place, tested, and accepted by the Engineer. Sanitary sewer will be measured longitudinally along the centerline of the sewer between the inside faces of the manholes.
- If the installation involves a connection to an existing sewer line, the measurement will be made from the end of the existing sewer line to the inside face of the manhole on the work being measured.
- Sanitary sewer pipe will be measured as described above and classified as sanitary sewers for the purposes of payment.
- Wyes, tees, and bends are subsidiary to this Item. Include them in the measurement for payment of pipe sewer main in which they are installed. Plugs are subsidiary to the pertinent bid items.
- 5.2 **Steel Casing** will be measured by the foot of the various sizes installed by the open cut method complete in place and accepted by the Engineer. Steel casing will be measured longitudinally along the centerline of the casing pipe. The conditions, etc., regarding the measurement of sanitary sewers stated under Section 5.1. above also apply to casing pipe.

- 5.3 **Manholes** will be measured by each manhole, of the various types specified, complete in place.
- 5.4 **Adjusting Manholes** will be measured by each manhole adjusted.
- 5.5 **Jacking, Boring, or Tunneling** for sanitary sewers and steel casing will be measured by the foot of the various sizes, types, and wall thickness (if applicable) specified of sanitary sewer or steel casing jacked, bored, or tunneled.
- 5.6 **Service Connections** will be measured by each complete disconnection (abandoned connection) or reconnection of the material, type, diameter, and depth range (0 to 10 ft., 10-15 ft., or greater than 15 ft.) specified for each sanitary sewer service. The depth will be measured from the natural ground level to the flow line of the sanitary sewer main at the point of reconnection, for the Contractor's information only. One or more connections discharging into a common point will be considered as one service connection.
- 5.7 **Abandoning Sanitary Sewers** will be measured by each sewer abandoned of the sizes specified.
- 5.8 **Cutting and Restoring Pavement** will be measured by the square yard, of the depths specified.
- 5.9 **Air Release and Vacuum Relief Valves** will be measured by each valve assembly installed of the various sizes and types specified.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit prices bid for the items described below. These prices are full compensation for furnishing materials and their preparation; for excavation and backfill; for preparation, shaping, and fine grading the bottom of the trench; for cutting and restoring existing pavement; for hauling, placing, and joining of pipes, valves, and fittings; for constructing bollards, vent piping, stacks, and manholes; and for necessary appurtenances and other items of materials, labor, equipment, tools, and incidentals.

- 6.1 **Sanitary Sewers.** Payment for sanitary sewers will be made at the unit price bid for "Sanitary Sewers" of the various sizes, types, and wall thickness (if applicable) specified, complete in place. Plastic liner is required for concrete pipe interior surfaces and is subsidiary to this bid Item. An internal liner resin is required for centrifugally cast fiberglass pipe and is subsidiary to this bid Item.
- Unless otherwise specified on the plans or this specification, excavation, disposing of unsuitable excavated material, backfilling, and the material used for backfill for the complete installation of the sanitary sewer system are subsidiary to and included in the unit price bid for the pipe and any structure for which payment is required.
- Fittings, including necessary concrete blocking, pipe clamps, nipples, pipe coatings, lubricants, etc., are subsidiary to the sanitary sewer mains in which they are installed. If additional fittings are required due to plan changes or alterations in line or grade, they will be subsidiary to the sanitary sewer lines in which they are installed.
- 6.2 **Steel Casing.** Payment for steel casing will be made at the unit price bid for "Casing (Steel)(Sanitary Sewer)" of the various sizes specified, installed by the open cut method, complete in place.
- 6.3 **Manholes.** Payment for manholes will be made at the unit price bid for "Manholes (Sanitary Sewer)" of the various types specified, complete in place. Rings, covers, and steps are subsidiary to this bid Item.
- 6.4 **Adjusting Manholes.** Payment for each manhole adjusted will be made at the unit price bid for "Adjusting Manholes (Sanitary Sewer)." The excavation and backfill required are subsidiary to this bid Item.

- 6.5 **Jacking, Boring, or Tunneling.** Payment for jacking, boring, or tunneling of sanitary sewer will be made at the unit price bid for “Jacking, Boring, or Tunneling (Sanitary Sewer)” of the various sizes, types, and wall thicknesses (if applicable) specified. This price includes furnishing the pipe.

Payment for jacking, boring, or tunneling steel casing will be made at the unit price bid for “Jacking, Boring, or Tunneling Casing (Steel) (Sanitary Sewer)” of the various sizes and wall thickness specified (applicable only if exceeding minimum thickness shown in Section 2.8., “Steel Casing Pipe,” of this specification). This price includes the steel casing.

Sanitary sewer placed in casing will be paid for at the unit price bid for “Sanitary Sewers” as described above.

Excavating, backfilling, backfill material, and disposing of the unsuitable excavated material caused by jacking, boring, or tunneling pipe or casing, are subsidiary to and included in the unit price bid for the pipe or casing jacked, bored, or tunneled.

- 6.6 **Service Connections.** Payment for service connections will be made at the unit price bid for “Service Connections (Sanitary Sewer).” This payment includes any sewer stacks required. Excavation and backfill associated with disconnection or reconnection are subsidiary to this bid item.

No separate payment will be made for an abandoned service connection if the service to be abandoned is within 4 ft. of an active connection. Payment for only one abandoned service connection will be allowed when a second abandoned connection is within 4 ft. of the first.

- 6.7 **Abandoning Sanitary Sewers.** Payment for abandoning sanitary sewer will be made at the unit price bid for “Abandoning Sanitary Sewer” of the sizes specified. Excavation and backfill required to abandon the sanitary sewer are subsidiary to this bid item. Where grout is required, as shown on the plans, it is subsidiary to this bid item.

- 6.8 **Cutting and Restoring Pavement.** Payment for cutting and restoring pavement will be made at the unit price bid for “Cutting and Restoring Pavement” of the depths specified. Excavation below the pavement and base is subsidiary to this bid item.

- 6.9 **Air Release and Vacuum Relief Valves.** Payment for Air Release and Vacuum Relief Valves will be made at the unit price bid for “Air Release Valve,” “Air Release and Vacuum Relief Valve,” or “Vacuum Relief Valve” of the various sizes specified. This price is full compensation for valves, fittings, vent piping, bollards, necessary appurtenances, and incidentals.

Trench excavation protection or temporary special shoring required for trenches which are greater than 5 ft. in depth, and sloping the sides of those trenches to preclude collapse, will be measured and paid for as required by Item 402, “Trench Excavation Protection” or Item 403, “Temporary Special Shoring.”

Furnishing and placing bedding material is subsidiary to the pertinent bid items.

Furnishing and installing a complete, operational nonmetallic pipe detection system, and the materials necessary for this system are subsidiary to the pertinent bid items.

Unless otherwise specified on the plans, repair curbs, pavement, base material, concrete riprap, and sidewalks damaged by construction operations at no expense to the Department, if such damaged items are not part of the Contract.

Testing sanitary sewers for leakage, including labor, materials, and equipment necessary to perform the tests, is subsidiary to the pertinent bid items.

Special Specification 7032

Water Mains and Service Lines



1. DESCRIPTION

Provide and install a complete water main system in accordance with the plans and specifications and in compliance with the local utility owner's policies, if any, and the Department's Utility Accommodation Policy (UAP)(Title 43, T.A.C., Sections 21.31-21.55). The water mains shall be of the sizes, materials and dimensions shown on the plans and shall include all pipe, all joints and connections to new and existing pipes, all valves, fittings, fire hydrants, pipe joint restraint systems, blocking, and incidentals, as may be required to complete the work.

The abbreviations AWWA, ASA, ASTM, and ANSI, as used in this specification, refer to the following organizations or technical societies:

1. AWWA - American Water Works Association
2. ASA - American Standards Association
3. ASTM - American Society for Testing and Materials
4. ANSI - American National Standards Institute
5. NSF - National Science Foundation

Where reference is made to specifications of the above organizations, it is to be construed to mean the latest standard in effect on the date of the proposal.

2. MATERIALS

Where specific products or manufacturers are mentioned in this specification, approved equals may be used.

3.1 Ductile-Iron Pipe and Fittings.

2.1.1. Ductile-Iron Pipe: 3-Inch through 64-Inch.

All ductile-iron pipe is to be manufactured by process of centrifugal casting and is to conform to AWWA Standard C-151, "American Standard for Ductile-Iron Pipe Centrifugally Cast with push-on or mechanical joints for Water or Other Liquids", unless otherwise modified or supplemented herein.

Pipe is to conform to the following pressure classes, based on Type 3 bedding conditions, a depth of bury of 6 feet and a working pressure of 150 psi:

Table 1	
3" through 12"	350 psi
16" through 20"	250 psi
24"	200 psi
30" through 64"	150 psi

Dimensions and tolerances for each nominal pipe size shall be in accordance with table 51.5 (push-on) or table 51.5 (mechanical joint) of AWWA Standard C-151 for pipe with a nominal laying length of 20 feet.

All pipe is to have a standard water works cement mortar lining in accordance with AWWA Standard C-104 with outside coating per Section 51.8.1 of AWWA Standard C-151.

Exterior coating is to consist of a nominal one mil thick asphaltic material applied to the outside of the pipe as described in Section 51.8 of AWWA Standard C-151.

Rubber joint gaskets utilized on ductile-iron pipe are to conform with AWWA Standard C-111.

Each length of pipe shall bear identification markings in conformance with Section 51.10 of AWWA Standard C-151.

The Contractor is to use a manufacturer that takes adequate measure during pipe production to assure compliance with AWWA Standard C-151 by performing quality-control tests and maintain results of those test as outlined in Section 51.14 of that standard.

The Engineer may at no cost to the Contractor, subject random lengths of pipe for testing by an independent laboratory for compliance with this specification. Any visible defects or failure to meet quality standards here in will be grounds for rejecting the pipe.

2.1.2. Fittings for Ductile-Iron Pipe.

Unless otherwise modified or supplemented herein, WWA Standard C-110 for Ductile-Iron Fittings, 3-inch through 48-inch for Water and Other Liquids" and AWWA Standard C-153 for Ductile-Iron Compact Fittings, is to govern the design, manufacture, and testing of all fittings under this specification.

For 3 through 24-inch size range, the pressure rating of all fittings is to be a minimum of 250 psi. The working pressure for all fittings of size greater than 24-inch is to be a minimum of 150 psi, unless a change in pressure rating is shown on the plans.

Fittings are to be furnished with the type of end combination specified.

Mechanical joint fittings and anchor type fittings are to be furnished complete, with glands, gaskets, and bolts. Bolts for mechanical joints are to be ASTM A-536 specially alloyed and heat treated ductile iron conforming to ANSI/AWWA Standard C111/A21.1L.

Flanged fittings are to be faced and drilled in accordance with ASA Specifications B 16.1, Class 125.

Anchor fittings are to be furnished in size and type or length as specified.

The exterior of all fittings is to be provided with a petroleum asphaltic coating in accordance with AWWA Standard C-110. The interior of flanged fittings supplied under this Item is to be either cement-mortar lined in accordance with AWWA Standard C-104 or lined with a petroleum asphaltic material in accordance with AWWA Standard C-110 as specified. The interior of all other fittings supplied under this Item is to be cement-mortar lined in accordance with AWWA Standard C-104.

Fittings for 2-inch size are to be manufacturer's standard design, designed in accordance with applicable design standard of AWWA Standard C-110.

3.2 Concrete Steel Cylinder Pipe and Fittings: 20-inch and larger.

The design, component materials, manufacture and testing of all concrete-steel cylinder pipe and fittings is to conform to AWWA Standard C-301 for "Pre-Stressed Concrete Pressure Pipe, Steel Cylinder Type, for Water and Other Liquids". Except where otherwise indicated in the contract documents, all pipe is to be

AWWA Class 150 and is to be designed for an internal working pressure of 150 psi and a minimum external load equivalent to 6-feet of earth cover. Where the depth of bury of the pipe is indicated to be greater than 6-feet in the contract specifications or on the drawings the design of the pipe is to be suitable for the earth loads indicated.

All data submitted by the Contractor is to include a tabulated layout schedule with reference to the stationing and grade lines shown on the plans. The Contractor is to provide a design summary for each size of pipe furnished for each pressure and depth of bury.

Each special length of straight pipe is to have plainly marked on the inside of the bell end the class of pipe and identification marks sufficient to show the proper location of the pipe by reference to layout drawings.

Pipe 20 through 42-inch in size is to be furnished in nominal lengths of 20 to 32 feet; pipe 48 through 72-inch in size is to be furnished in nominal lengths of 16-feet except as this requirement is to be modified by design requirements of the particular job.

Each joint of pipe is to be furnished with a rubber gasket and a 12-inch diaper.

3.3

Steel Pipe, Fittings and Flanges.

- 2.3.1. Steel Pipe. Steel pipe with nominal diameters from 6 through 20-in. shall conform to ASTM A 106, A 53 Grade B or A 139 Grade B standard weight class as the minimum

Steel Pipe greater than 20-inches shall conform to AWWA C-200 and AWWA M-11 except as modified herein or as required by the Engineer for special circumstances.

Pipe shall be designed for a minimum of 150 psi working pressure with an additional 50% of the working pressure allowance for surge pressure unless otherwise specified. Pipe design shall be in accordance with AWWA M-11.

Pipe shall be designed to cover conditions as shown on the plans. The design for deflection shall be in accordance with AWWA M-11.

Pipe for use with sleeve-type couplings shall have plain ends at right angles to the axis.

Pipe ends are to be beveled and suitable for field butt welding except as otherwise specified.

Protective coatings and linings are to conform to AWWA Standard C-203, "Coal-Tar Protective Coatings and Linings for Steel Pipelines - Enamel and Tape Hot Applied".

Pipe length is to be nominal 50-foot lengths except for specials or as otherwise specified on the plans. Contractor is to prepare a lay schedule showing the location of each piece by a mark number with station and invert elevation at each bell end.

2.3.2.

Fittings for Steel Pipe.

Unless otherwise shown on the Plans, all specials and fittings shall conform to the dimensions of AWWA Standard C-208. Pipe material used in fittings shall be of the same material and thickness as the pipe. The minimum radius of elbows shall be 2.5 times the pipe diameter and the maximum miter angle on each section of the elbow shall not exceed 11 1/4 degrees (One cut elbow up to 22 1/2 deg.). If elbow radius is less than 2.5 x pipe diameter, stresses shall be checked per AWWA M-11 and wall thickness or yield strength increased if necessary. Fittings shall be equal in pressure design strength. Specials and fittings, unless otherwise shown on the Plans, shall be made of segmentally welded sections from hydrostatically tested pipe, with ends compatible with the type of joint or coupling specified for the pipe. All welds made after hydrostatic testing of the straight sections of pipe shall be checked per the requirements of AWWA C-200 Section 5.2.2.1.

- 2.3.2.1. Rolled-Groove Rubber Gasket Joint: the standard joint shall be rolled-groove rubber gasket joint unless otherwise noted on the plans. Rolled-grooved rubber gasket joints shall conform to AWWA C-200 Standard and as shown in Chapter 8 of AWWA M-11.

The o-ring rubber gasket shall have sufficient volume to approximately fill the area of the groove and shall conform to AWWA C-200.

The joint shall be suitable for a safe working pressure equal to the class of pipe furnished and shall operate satisfactorily with a deflection angle, the tangent of which is not to exceed $1.00/D$ where D is the outside diameter of the pipe in inches with a pull-out of 1 inch.

Rolled-Groove Rubber Gasket Joints may be furnished only by a manufacturer who has furnished pipe with joints of similar design for comparable working pressure, pipe diameter, pipe length, and wall thickness that has been in successful service for a period of at least 5 years. If requested provide documentation of compliance with this requirement.

- 2.3.2.2. Lap weld: Lap field welded joints shall be used where tied joints are indicated on the plans. The standard bell shall provide for a 2 1/2-inch lap. The minimum lap shall be 1 inch. The design maximum joint deflection or offset shall be a 1" joint pull.

- 2.3.2.3. Mechanical Couplings: Mechanical couplings where indicated on the plans shall be Smith Blair Style 411, Baker Style 200, Brico Depend-O-Loc or equal. Insulating mechanical couplings where indicated on the plans shall be double insulated Smith Blair Style 416, Baker Style 216, or equal. Mechanical couplings shall be rated to meet or exceed the working pressures and surge pressure of the pipe.

Couplings for buried service shall have all metal parts painted with epoxy paint and conform to AWWA C-219.

Pipe ends for mechanical couplings shall conform to AWWA C-200 and M-11. The shop applied outside coating shall be held back as required for field assembly of the mechanical coupling or to the harness lugs or rings.

Harness lugs or rings and pipe ends shall be painted with one shop coat of epoxy conforming to AWWA C-210. The inside lining shall be continuous to the end of the pipe.

- 2.3.3. Steel Flanges - Steel pipe flanges, where called for on the plans, are to conform to AWWA Standard C-207, "Steel Pipe Flanges" for Class D for operating pressures to 175 psi on 4 inch through 12 inch diameter, and operating pressures to 150 psi on diameters over 12 inches; or flanges shall be AWWA C-207 Class E for operating pressures up to 275 psi; or flanges shall be AWWA C-207 Class F for pressures to 300 psi. (drilling matches ANSI B 16.5 Class 250).

Shop lining and coating shall be continuous to the end of the pipe or back of the flange. Flange faces shall be shop coated with a soluble rust preventive compound.

Gaskets: Full face, 1/8-inch thick, cloth-inserted rubber, Garlock 3000, John Crane Co. Style 777 or equal.

Bolts and Nuts for Flanges

- 2.3.3.1. Bolts for flanges located indoors and in enclosed vaults and structures shall be carbon steel, ASTM A-307, Grade B for class B and D flanges and nuts shall be ASTM A-563, Grade A heavy hex. Bolts for class E and F flanges shall be ASTM A-193 grade B7 and nuts shall be ASTM A-194, grade 2 H, heavy hex.
- 2.3.3.2. Bolts for buried and submerged flanges and flanges located outdoors above ground or in open vaults in structures shall be Type 316 stainless steel conforming to ASTM A-193, Grade B8M, Class 1 for class B and D Flanges with ASTM A-194, Grade 8M nuts. For Class E and F flanges the bolts shall be ASTM A-194 grade 2H nuts with bolt and nuts to be zinc plated in accordance with ASTM B-633.

- 2.3.4. Linings and Coatings.
 - 2.3.4.1. Polyethylene Tape Coating:
 - 2.3.4.1.1. Prefabricated Multi-layer Cold Applied Tape Coating - the coating system for straight-line pipe shall be in accordance with AWWA Standard C-214. The system shall consist of three layers of polyethylene material with a nominal thickness of 80 mills when complete
 - 2.3.4.1.2. Coating Repair: Coating repair shall be made using tape and primer conforming to AWWA Standard C-209, Type II. The tape and primer shall be compatible with the tape system used for straight-line pipe.
 - 2.3.4.1.3. Coating of Fittings, Specials and Joints:
 - 2.3.4.1.3.1. General – Fittings, specials and joints which cannot be machine coated in accordance with above, shall be coated in accordance with AWWA Standard C-209. Prefabricated tape shall be Type II and shall be compatible with the tape system used for straight-line pipe. The system shall consist of 3 layers consisting of the following: Alternate coating methods for fittings specials and field joints would be Shrink sleeves per C-216, or paint per C-210, C-218, or C-222. The field coating shall completely encapsulate the joint bonds on o-ring joints.
 - 2.3.4.1.3.2. Coating Repair – Coating repair for fittings and specials shall be in accordance with the procedure described above for straight-line pipe and as recommended by the manufacturer.
 - 2.3.4.2. Other Coating Systems if specified shall be governed by the appropriate American Water Works Association standard.
 - 2.3.4.3. Cement Mortar per AWWA C-205
 - 2.3.4.3.1. Cement Mortar Lining of Steel Pipe
 - 2.3.4.3.1.1. Except as otherwise provided in AWWA Standard C-205, interior surface of all steel pipe, fittings, and specials shall be cleaned and lined in the shop with cement-mortar lining applied centrifugally in conformity with AWWA Standard C-205.
 - 2.3.4.3.1.2. The pipe ends shall be left bare where field joints occur as shown on the plans. Ends of the linings shall be left square and uniform. Feathered or uneven edges will not be permitted.
 - 2.3.4.3.1.3. Defective linings as identified in AWWA C-205 shall be removed from the pipe wall and shall be replaced to the full thickness required. Defective linings shall be cut back to a square shoulder in order to avoid feather edged joints.
 - 2.3.4.3.1.4. Cement mortar lining shall be kept moist during storage and shipping.
 - 2.3.4.3.2. Fittings
 - 2.3.4.3.2.1. Fittings shall be lined and coated per AWWA C-205.
- 2.3.5. Steel Casing Pipe.

The component materials, manufacture and testing of all steel pipe will conform to AWWA Standard C-200 for "Steel Water Pipe 6-in. and Larger". The specified pipe size will be the actual inside diameter of the pipe, special or fitting in inches. The diameter and wall thickness of all steel pipe will conform to those shown on the plans.

Pipe will be either Grade A or Grade B, conforming to ASTM Designation A-53.

Pipe ends will be beveled and suitable for field butt welding except as otherwise specified.

Pipe will receive a protective coating conforming to AWWA Standard C-203, "Coal-Tar Protective Coatings and Linings for Steel Pipelines – Enamel and Tape Hot Applied".

Pipe length will be nominal 40 ft. lengths except for specials or as otherwise specified on the plans. Standard and specials will be within 1/16-in. (plus or minus) of the specified or theoretical lengths.

2.3.6. Stainless Steel Casing Spacer.

The casing spacers are to be constructed of T-304 stainless steel segments which bolt together forming a shell around the carrier pipe. The spacers are to be designed with risers (when needed) and runners to support the carrier within the casing and maintain a minimum clearance of 0.50-inch between the casing ID and the spacer OD. On carrier pipes with an OD less than 16-inches., each spacer is to have four (4) riser and runner combinations - two (2) on each segment. On carrier pipes with an OD of 16-in. and larger, each spacer is to contain six (6) riser and runner combinations - four (4) on the bottom segment and two (2) on the top segment. T-304 stainless steel bolts and nuts are to be supplied with the spacers.

The band is to be manufactured of 8-inch wide, 14 gauge, T-304 stainless steel material. The risers are to be constructed of 10 gauge, T-304 stainless steel having a minimum length of 6-inches.

Abrasion resistant runners, having a minimum length of 7-inches and a minimum width of 1-inch are to be attached to each riser to minimize friction between the casing pipe and the carrier pipe as it's installed. Runner material is to be of glass reinforced plastic with compression strength of 25,000 psi, flexural strength of 32,000 psi and tensile strength of 22,000 psi. The ends of all runners are to be beveled to facilitate installation over rough weld beads or the welded ends of misaligned or deformed casing pipe.

Interior surfaces of the circular steel shell are to be lined with PVC or EPDM having a minimum thickness of 0.090-inch with a hardness of durometer "A" 85-90.

Spacers will be placed a maximum of 1-foot on each side of the bell joint and every 8 to 12-feet apart thereafter.

Physical Properties

- 2.3.6.1. Band and Risers
 - 2.3.6.1.1. Band - 14 Gauge, T-304 Stainless Steel
 - 2.3.6.1.2. Riser - Minimum 14 Gauge, T-304 Stainless Steel
- 2.3.6.2. Liner - EPDM or Polyvinyl Chloride
 - 2.3.6.2.1. Thickness - 0.090-in. minimum
 - 2.3.6.2.2. Hardness - Durometer "A" 85-90
 - 2.3.6.2.3. Dielectric Strength - 1/8-in. thick
 - 2.3.6.2.4. 60,000 VPM
 - 2.3.6.2.5. Water Absorption - one (1) percent maximum
 - 2.3.6.2.6. Overlap edges
- 2.3.6.3. Studs, Nuts and Washers

- 2.3.6.3.1. T-304 Stainless Steel - 5/16: - 18-in. x 2-in. studs
- 2.3.6.3.2. 5/16-in. hex nuts
- 2.3.6.3.3. 5/16-in. washers SAE 2330
- 2.3.6.4. Runners
- 1-in. wide or 2-in. wide glass filled polymer runners
- Sizes Available:
- Length - 7-in.
- Effective heights (all lengths) - 1-in. and 1 1/2-in.
- Materials Specifications:
- Tensile Strength (ASTM D-638) - 22,000 psi
- Flexural Strength (ASTM D-790) - 32,000 psi
- Compression Strength (ASTM D-695) - 25,000
- Deflection Temperature @ 264 psi (ASTM D-648) - 435 F (224 C)
- Deformation Under Load, @ 122 F (50C) - 4000 pound Load, - (ASTM D-648) 1.2 percent.
- 2.3.6.5. Welding. All risers are to be welded by MIG welding. Welds are to be fully passivated.
- 2.3.7. Quality Assurance Commercial Standards. (All manufacturing tolerances referenced in the below standards apply unless specifically excluded).
- ANSI/AWWA C-200 Standard for Steel Water Pipe 6 Inches and Larger.
- ANSI/AWWA C-205 Standard for Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 inch and Larger-Shop Applied
- ANSI/AWWA C-206 Standard for Field Welding of Steel Water Pipe.
- ANSI/AWWA C-207 Standard for Steel Pipe Flanges for Water Works Service, 4" - 144".
- ANSI/AWWA C-208 Standard for Dimensions for Fabricated Steel Water Pipe Fittings.
- ANSI/AWWA C-209 Standard for Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines.
- ANSI/AWWA C-210 Standard for Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines.
- ANSI/AWWA C-214 Standard for Tape Coating Systems for the Exterior of Steel Water Pipelines.
- ANSI/AWWA C-216 Standard for Heat-Shrinkable Cross-Linked Polyolefin Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines.

ANSI/AWWA C-218 Standard for Liquid Coating the Exterior of Aboveground Steel Water Pipelines and Fittings.

ANSI/AWWA C-219 Standard for Bolted Sleeve-Type Couplings for Plain-End Pipe.

ANSI/AWWA C-222 Standard for Polyurethane Coatings for the Interior and Exterior of Steel Water Pipelines and Fittings.

AWWA M-11 Steel Pipe - A guide for Design and Installation

ASTM A-106 Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.

ASTM A-53 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated Welded and Seamless.

ASTM E-165 Method for Liquid Penetrant Examination.

ASTM E-709 Guide for Magnetic Particle Examination.

ASME Section V Nondestructive Testing Examination.

ASME Section IX Welding and Brazing Qualification.

AWS B2.1 Standard for Welding Procedure and Welding Qualifications.

2.3.8. Qualifications

2.3.8.1. The pipe and fittings shall be designed, constructed and installed in accordance with the best practices and methods and shall comply with these specifications as applicable.

2.3.8.2. Pipe shall be the product of one manufacturer. All pipe manufacturing including cylinder production, lining, coating and fittings shall be produced by one manufacture. The pipe manufacturer must have a certified quality assurance program. This certified program shall be ISO 9001: 2000 or other equivalent nationally recognized program.

3.4 **Polyvinyl Chloride Pipe and Fittings.**

2.4.1. Polyvinyl Chloride Pipe, 2-inch through 12-inch (ASTM 2241).

2-inch through 12-inch polyvinyl chloride (PVC) pressure pipe is to be made from class 12454A or 12454B compounds as determined by ASTM Standard D-1784 and providing for a hydrostatic test basis (HBD) of 4000 psi.

All PVC pipe shall conform to applicable AWWA standards. The Contractor shall supply the Engineer a manufacturer's affidavit that the materials supplied comply with all applicable requirements of AWWA.

All ASTM 2241 PVC pipe shall have a standard dimension ratio (SDR) of 26 (160 psi pressure class) or an SDR of 21 (200 psi pressure class). All PVC pipe 4" and smaller shall have an SDR of 21. It shall be furnished in nominal 20-foot lengths, and shall be self extinguishing.

Dimensions and tolerances for each nominal pipe size are to be in accordance with PVC Pipe Dimensions as published in the Handbook of PVC Pipe, as published by the Uni-Bell Plastic Pipe Association.

Each pipe shall have an integral bell formed on the pipe end, and be designed to be at least as strong as the pipe wall.

An elastomeric gasket shall be designed with a retainer ring that locks the gasket into integral bell groove and shall be installed at the point of manufacture. The dimensions and design of the gasket joint provided for the PVC pipe shall meet requirements provided in ASTM D-3139 and ASTM D-2122. The gasket shall be reinforced with a steel band and shall conform to ASTM F-477.

Each length of pipe furnished is to bear identification markings in conformance with Section 2.6 of AWWA C-900.

2.4.2. Polyvinyl Chloride Pipe, 4-inch through 12-inch (C-900).

4-inch through 12-inch polyvinyl chloride (PVC) pressure pipe is to be made from class 1245A or 1245B compounds as determined by ASTM Standard D-1784 and providing for a hydrostatic test basis (HBD) of 4000 psi.

All PVC pipe shall conform to AWWA Standard C-900. The Contractor shall supply the Engineer a manufacturer's affidavit that the materials supplied comply with all applicable requirements of AWWA.

All AWWA C-900 PVC pipe shall have a pressure rating of 150 psi and a dimension ratio of 18 with cast iron equivalent outside diameters unless otherwise specified. It shall have a sustained pressure requirement of 500 psi and a minimum burst pressure of 755 psi. AWWA C-900 PVC pipe installed in High Pressure Zones to have a pressure rating of 200 psi and a dimension ratio of 14, a sustained pressure requirement of 650 psi and a minimum burst pressure of 985 psi. It shall be furnished in nominal 20-foot lengths, and shall be self extinguishing.

Dimensions and tolerances for each nominal pipe size are to be in accordance with Section 2.2, Table 1 of AWWA C-900.

Each pipe shall have an integral bell formed on the pipe end, and be designed to be at least as strong as the pipe wall.

An elastomeric gasket shall be designed with a retainer ring that locks the gasket into integral bell groove and shall be installed at the point of manufacture. The dimensions and design of the gasket joint provided for the PVC pipe shall meet requirements provided in ASTM D-3139 and ASTM D-2122. The gasket shall be reinforced with a steel band and shall conform to ASTM F-477.

Each length of pipe furnished is to bear identification markings in conformance with Section 2.6 of AWWA C-900.

2.4.3. Polyvinyl Chloride (PVC), 14-inch through 36-inch

2.4.3.1. Scope. This product specification covers 14-inch nominal diameter through 36-inch nominal diameter polyvinyl chloride (PVC) potable water transmission pipe with integral bell and spigot joints. The pipe shall be extruded from Class 12454-A or 12454-B PVC compound as defined in ASTM D-1784 and provide for a hydrostatic design basis (HDB) of 4,000 psi. The pipe outside diameters shall conform to dimensions of cast iron pipe (CI). All pipe furnished shall be in conformance with AWWA C-905-97, or latest revision thereof.

Pipe shall be homogenous throughout. It shall be free from voids, cracks, inclusions, and other defects. It shall be as uniform as commercially practical in color, density, and other physical properties. Pipe surfaces shall be free from nicks and scratches. Joining surfaces of spigots and joints shall be free from gouges and imperfections that could cause leakage.

2.4.3.2. Definitions. All definitions are defined according to AWWA C-905-97 Section 1.2 Definitions.

2.4.3.2.1. Dimension Ratio (DR) – The ratio of the pipe outside diameter to the minimum wall thickness. The quotient is rounded to the nearest 0.5 when necessary.

- 2.4.3.2.2. Pressure Rating (PR) – The nominal pressure rating of transmission pipe is determined from formulas in Section 5: Transmission-Pipe Ratings AWWA C905-97 using a safety factor of 2.0. There is no allowance for surge pressure in the pressure rating.
- 2.4.3.3. General
- 2.4.3.3.1. Except as noted on the plans or specifications for specific jobs, all C-905 PVC pipe shall have a pressure rating of 235 PSI and a dimension ratio of 18 or have the highest pressure rating available for each size of pipe.
- 2.4.3.3.2. Dimensions and tolerances for each nominal pipe size shall be in accordance with Table 2 Dimensions for PVC Transmission Pipe with CI Outside Diameter of Section 3 Pipe Requirements in AWWA C-905-97. All pipe shall be suitable for use as a pressure conduit.
- 2.4.3.3.3. Pipe shall be gauged full length and furnished in standard laying lengths of 20 feet \pm 1 in. unless otherwise noted. Each pipe shall have an integral bell formed on the pipe end, and be designed to be at least as strong as the pipe wall.
- 2.4.3.3.4. An elastomeric gasket shall be designed with a retainer ring, which locks the gasket into integral bell groove and shall be installed at the point of manufacture. The dimensions and design of the gasket joint provided for the PVC transmission pipe shall meet requirements provided in ASTM D-3139 and ASTM D-2122. The gasket shall be reinforced with a steel band and shall conform to ASTM F-477.
- 2.4.3.3.5. Each length of pipe furnished shall bear identification markings that will remain legible after normal handling, storage, and installation. Markings shall be applied in a manner that will not weaken or damage the pipe. Markings shall be applied at intervals of not more than 5 ft. on the pipe. The minimum required markings are given in the list below. Marking requirements shall be in conformance with Section 4.7 Marking Requirements of AWWA C-905-97.
- 2.4.3.3.5.1. Nominal size and OD base (for example, 24 CI).
- 2.4.3.3.5.2. PVC.
- 2.4.3.3.5.3. Dimension Ratio (for example, DR 25).
- 2.4.3.3.5.4. AWWA pressure rating (for example, PR 165).
- 2.4.3.3.5.5. AWWA designation number for this standard (AWWA C-905).
- 2.4.3.3.5.6. Manufacturer's name or trademark.
- 2.4.3.3.5.7. Manufacturer's production code, including day, month, year, shift, plant, and extruder of manufacture.
- 2.4.4. AWWA C-900 and C-905 Requirements
- 2.4.4.1. Bundle pipe in pallets for ease of handling and storage. Package pipe bundles to provide structural supports to insure that weight of upper units do not cause deformation to pipe in lower units.
- Pipe bundles showing evidence of ultra violet radiation "sunburn" on exposed pipe as may be caused from extended unprotected storage conditions will not be accepted.
- 2.4.4.2. The pipe must be in compliance with AWWA Standards C-900 or C-905-97 as applicable by performing quality control-control test and maintaining results of those test as outlined in Section 3 of that standard. Submission of product constitutes certification of compliance with standard.

- 2.4.4.3. Pipe is intended for use as an underground, direct bury pressure pipe for transport of potable water. The expected life of pipe system after installation is 25 to 50 years.
- 2.4.4.4. Provide a one year warranty for all material sold and delivered for use and incorporation into water system. Warranty takes effect on the date that pipe is accepted by the Department.
- 2.4.4.5. Test.
 - 2.4.4.5.1. For both C-900 and C-905, water system may at no cost to the Contractor, subject random lengths of pipe for testing by an independent laboratory for compliance with this specification. Any visible defects of failure to meet quality standards here in will be grounds for rejecting entire order.
 - 2.4.4.5.2. For C-905: The Contractor shall ensure that the manufacturer pressure tested all pipe, including the joint, which is marked with the designation number of AWWA C-905-97 at 73.4° F. +/- 3.6°F (23°C +/- 2°C). Each length of pipe shall be proof tested at twice the pressure rating listed in Table 3 Transmission-Pipe Pressure Rating of AWWA C-905-97 Sec. 4.6 Pressure Strength and Hydrostatic Proof
- 2.4.4.6. References. The documents listed below are referenced in this specification.
 - 2.4.4.6.1. AWWA C-905-97; Polyvinyl Chloride (PVC) Water Transmission Pipe Nominal Diameters 14 inch through 36 inch.
 - 2.4.4.6.2. ASTM D-1784; Standard Specification for Rigid Polyvinyl Chloride (PVC) Compounds and Chlorinated Polyvinyl Chloride (CPVC) Compounds.
 - 2.4.4.6.3. ASTM D-2122; Standard Method of Determining Dimensions of Thermoplastic Pipe and Fittings.
 - 2.4.4.6.4. ASTM D-3139; Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.
 - 2.4.4.6.5. ASTM F-477; Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
- 2.4.5. Bends and Fittings for PVC Pipe 4-inch through 36-inch. All bends and fittings shall conform to the same requirements subparagraphs 2.A.2 Fittings for Ductile-Iron Pipe.
- 2.4.6. Joint Restraint System for PVC C-900/C-905.
 - 2.4.6.1. Scope. This specification covers pipe joint restraint systems to be used on domestic water mains for PVC C-900 pipe sizes 4-inch through 12-inch diameter and PVC C-905 pipe sizes 16-inch through 24-inch diameter, and for Ductile Iron pipe sizes from 4-inch through 24-inch diameter.

Joint restraint systems are classified as "compression, "mechanical joint" or "non-metallic restrained joint" for the specific type of pipe joint to be restrained.
 - 2.4.6.2. General Requirements
 - 2.4.6.2.1. Underwriter Laboratories (U.L) and Factory Mutual (FM) certifications are required on all restraint systems.
 - 2.4.6.2.2. Unless otherwise noted, restraint systems to be used on PVC C-900 and C-905 pipe shall meet or exceed A.S.T.M. Standard F1674-96, "Standard Test Methods for Joint Restraint Products for Use with PVC Pipe," or the latest revision thereof. Restraint systems used on ductile pipe shall meet or exceed U.L. Standard 194
 - 2.4.6.2.3. Non-metallic restrained joint pipe and couplings shall be utilized specifically for C-900 PVC pipe and fittings in sizes 4-inch-12-inch.
 - 2.4.6.2.4. Each restraint system shall be packaged individually and include installation instructions.

- 2.4.6.3. Specific Requirements.
- 2.4.6.3.1. Restrainer for PVC C-900/C-905 & Ductile Iron Push-on Type Connections:
- 2.4.6.3.1.1. Pipe restraints shall be utilized to prevent movement for push-on D.I. or PVC (C-900&C-905) (compression type) bell and spigot pipe connections or where a transition or flexible coupling has been used to join 2 sections of plain-end pipe D.I. or PVC (C-900&C-905). The restrainer may be adapted to connect a plain end D.I. or PVC pipe to a ductile iron mechanical joint (MJ) bell fitting. The restrainer must not be directionally sensitive.
- 2.4.6.3.1.2. The pipe shall be restrained by a split retainer band. The band shall be cast ductile iron, meeting or exceeding ASTM A-536-80, Grade 65-45-12. The inside face or contact surface of the band shall be of sufficient width to incorporate cast or machined non-directionally sensitive serration to grip the outside circumference of the pipe. The serration shall provide full (360 °) contact and maintain pipe roundness and avoid any localized points of stress. The split band casting shall be designed to “bottom-out” before clamping bolt forces (110ft-lb minimum torque) can over-stress the pipe, but will provide full non-directionally sensitive restraint at the rated pressures.
- 2.4.6.3.1.3. Bolts and nuts used to attach the split retainer ring shall comply with ANSI B-18.2/18.2.2, SAE Grade 5. Tee-bolts, nuts and restraining rods shall be fabricated from high-strength, low-alloy steel per AWWA C-111-90, ANSI/AWWA C-111/A-21.11.
- 2.4.6.3.1.4. The split ring type non-directionally sensitive restrainer system shall be capable of a test pressure twice the maximum sustained working pressure listed in section D and be for both D.I. and/or PVC C-900.
- 2.4.6.3.1.5. Restraint systems sizes 6 through 12-inch shall be capable of use for both ductile iron and/or PVC C-900.
- 2.4.6.3.1.6. The restraint system may consist of 2 types: the two split retainer rings and for new construction use only the 1 split and 1 solid cast backup ring.
- 2.4.6.3.2. Compression Ring Fitting Restrainer for Ductile Iron Pipe & PVC C-900.
- 2.4.6.3.2.1. Compression ring with follower gland type of restrainer may be utilized in conjunction with Mechanical Joint (MJ) bell end ductile iron pipe fittings for restraining PVC C-900 and ductile iron pipe.
- 2.4.6.3.2.2. The system shall utilize a standard MJ gasket with a color-coded compression ring and replacement gland conforming to ASTM A-536-80, Grade 65-45-12.
- 2.4.6.3.2.3. Standard MJ fitting Tee-bolts and nuts shall be fabricated from high strength steel conforming to ANSI AWWA C-111/A-21.11 and AWWA C-153/A-21.53-88.
- 2.4.6.3.2.4. Standard MJ gasket shall be virgin SBR meeting ASTM D-2000 3 BA 715 or 3 BA 515.
- 2.4.6.3.2.5. The restraint system shall be capable of a test pressure twice the maximum sustained working pressure shown in Table 2 below.
- 2.4.6.3.3. Non-metallic restrained joint pipe and couplings for PVC C-900 Type Connections:
- 2.4.6.3.3.1. Gasketed restrained coupling connections shall join two sections of factory grooved PVC (C-900) pipe. The restrainer coupling must not be directionally sensitive.
- 2.4.6.3.3.2. The coupling shall incorporate twin elastomeric sealing gaskets meeting the requirements of ASTM F-477 and shall be DR-14 Class 200 C-900 PVC in all applications, meeting or exceeding the performance requirements of AWWA C-900, latest revision. The inside face or contact surface of the coupling connection shall be of sufficient width to incorporate a factory machined non-directionally sensitive groove in both pipe and coupling to grip the outside circumference of the pipe. The couplings shall provide full (360 °) contact

and maintain pipe roundness and avoid localized points of stress. The coupling shall be designed with an internal stop to align the precision-machined grooves in the coupling and pipe prior to installation of a non-metallic thermoplastic restraint spline, and will provide full non-directionally sensitive restraint at the rated pressures.

- 2.4.6.3.3.3. High-strength flexible thermoplastic splines shall be inserted into mating precision-machined grooves in the pipe and coupling to provide full non-directional restraint with evenly distributed loading.
- 2.4.6.3.3.4. The non-metallic restrained joint pipe and couplings for PVC C-900 type non-directionally sensitive restrainer system shall be capable of a test pressure twice the maximum sustained working pressure listed in Section D and be for PVC (C-900) pipe sizes 4 through 12-inch.
- 2.4.6.3.3.5. Non-metallic restrained joint pipe and couplings for PVC C-900 restrained systems sizes 4 through 12-inch shall be capable of use for both Class 150 (DR 18) and 4 through 8-inch for Class 200 (DR 14) PVC C-900 pipe.
- 2.4.6.3.3.6. The non-metallic restrained joint pipe and couplings for PVC C-900 restraint system shall consist of a pipe and couplings system produced by the same manufacturer meeting the performance qualifications of Factory Mutual (FM) and Underwriters Lab (UL).
- 2.4.6.3.4. Retainer Gland for Ductile Iron Pipe (only):
 - 2.4.6.3.4.1. Radial bolt type restrainer systems shall be limited to ductile iron pipe in conjunction with Mechanical Joint (MJ) bell end pipe or fittings. The system shall utilize a standard MJ gasket with a ductile iron replacement gland conforming to ASTM A-536-80. The gland dimensions shall conform to Standard MJ bolt circle criteria.
 - 2.4.6.3.4.2. Individual wedge restrainers shall be ductile iron heat treated to a minimum hardness of 370 BHN. The wedge screws shall be compressed to the outside wall of the pipe using a shoulder bolt and twist-off nuts to insure proper actuating of the restraining system.
 - 2.4.6.3.4.3. Standard MJ fitting Tee-bolts and nuts shall be high strength steel conforming to AWWA C111/A21.11 and C153/A21.53-88.
 - 2.4.6.3.4.4. Standard MJ gasket shall be virgin SBR meeting ASTM D-2000 3 BA 715 or 3 BA 515.
- 2.4.6.3.5. Maximum Sustained Working Pressure Requirement

Table 2		
Nominal Diameter	PVC C-900 / C-905	Ductile Iron
4 & 6 in.	150 p.s.i. (DR18) / 200 p.s.i. (DR14)	350 p.s.i.
8 in.	150 p.s.i. (DR18) / 200 p.s.i. (DR14)	250 p.s.i.
10 & 12 in.	150 p.s.i. (DR18) / 200 p.s.i. (DR 14)	200 p.s.i.
14 & 16 in.	150 p.s.i. (DR 18) / 200 p.s.i. (DR 21) / 235 p.s.i. (DR 18)	200 p.s.i.
20 & 24 in.	150 p.s.i. (DR18) / 200 p.s.i. (DR 21) / 235 p.s.i. (DR18)	200 p.s.i.

- 2.4.6.3.6. Tests. The Engineer may, at no cost to the Contractor, subject random joint restraint system products to testing by an independent laboratory for compliance with these standards. Any visible defect of failure to meet the quality standards herein will be ground for rejecting the entire order.
- 2.4.6.3.7. Product List. Other approved equal products from other manufacturers meeting these specifications may be submitted for review.

2.4.6.3.7.1. Slip on Joint Restraint Systems:

Table 3			
Manufacturer	PVC C-900/C-905	Ductile Iron (D.I.)	D.I., 16" Above
Ford / Uni-Flange Corporation	Series 1390C	Series 1390C	1390C
EBBA Iron Sales, Inc.	1500	1700	1700
Romac Industries, Inc. 4-8 inch	Model 611	Model,611	47 OSJ
Star Pipe Products	1100	1100	1100

2.4.6.3.7.2. Compression Ring Systems:

Table 4		
Manufacturer	PVC C-900	Ductile Iron
Romac Industries, Inc.	Grip Ring-DI	Grip Ring-DI
Tyler Corporation	MJR Gland	MJR Gland
Star Pipe Products	Ring Lock 3500 Series	

2.4.6.3.7.3. Non-metallic restrained joint pipe and couplings for PVC C-900 RJ Type Connections:

Table 5		
Manufacturer	PVC C-900	Ductile Iron
CertainTeed Corporation, Certa-Lok C-900/RJ	4" – 12"	Class 150 (DR-18)
	4" – 8"	Class 200 (DR-14)

2.4.6.3.7.4. Retainer Gland (MJ):

Table 6		
Manufacturer	PVC C-900	Ductile Iron
EBBA Iron Sales, Inc.	2000 PV	MEGALUG 1100
Romac Industries, Inc.	Not Approved	Not Approved
Ford/UniFlange	UFR-1500-C 4" – 24"	Series 1400
StarPipe Products	Stargrip 4000	Stargrip 4000
Sigma Corporation	One Lok SLC	One Lok SLD

2.4.6.3.7.5. Restrained Flange Adapters:

Table 7		
Manufacturer	PVC C-900	Ductile Iron
EBBA Iron Sales, Inc.	2100 Megaflange	2100 Megaflange
Ford/UniFlange	900	200, 400, 420

3.5 Copper Tubing and Brass Fittings for Copper Service Lines.

2.5.1. Copper Tubing. All 3/4 in., 1 in., 1-1/2 in. and 2-in. copper tubing for underground service is to be of the type commercially known as Type "K" soft and conform to ASTM Designation B-88 and NSF Standard 61.

3/4 in. and 1-in. copper tubing is to be furnished in 60-foot coils or 100-foot coils as specified, 1-1/2-in. is to be furnished in 20-foot lengths, 40-foot coils or 60-foot coils as specified, and 2-in. is to be furnished in 20-foot lengths or 40-foot coils as specified.

2.5.2. Brass Fittings.

2.5.2.1. General requirements

Unless otherwise modified herein, water works brass goods consisting of corporation stops, curb stops, couplings, connectors, nipples, etc., will be required in underground installations of service lines in the water distribution system.

The brass composition is to conform to ASTM Designation B-62 and the threads are to conform to AWWA Standard C-800-01 for "Threads for Underground Service Line Fittings".

All casting is to have a natural, clean uniform and smooth surface, and be free from internal porosity.

All machining is to be done in a workmanlike manner and within the acceptable tolerances.

Unless otherwise specified each fitting is to be furnished with a 1/16-in. thick fiber gasket.

2.5.2.2. Design Criteria for Curb Stop/Angle Valves Ball Type

All Curb Stop, Corporation and Angle valves shall be ball valves. "Inverted/Ground Key," type angle valves will not be accepted.

Ball angle valves will not have a stop.

Laying dimensions the same as present inverted key style or equal to Mueller H-14258.

Reduced port design will be acceptable provided there is no compromise on flow capacity compared to the "Inverted/ Ground Key" type angle valve.

Pack joints will not be acceptable.

APPROVED MANUFACTURER LIST

In Line FIP X FIP

Table 8	
Approved Manufacturers and Models:	
2-INCH FIP X FIP	
Manufacturer	Model
Ford Meter Box	B11777WR
A.Y. McDonald	6111W
Mueller	B-20200-3
James Jones	J1900

Table 9				
Angle Curb Stop Meter Coupling x Compression				
Approved Manufacturers and Models				
Manufacturer	Size			
	3/4"	1"	1.5"	2"
A.Y. McDonald	4652BQ	4652BQ		4612BQ
Ford Meter Box	BA43-232WRQ	BA43-344WRQ	BFA43-666WRQ	BFA43777WRQ
Mueller	B24258-R3	B24258-3	B24276-3	B24276-3
James Jones	J1963WSG	J1963WSG	J1975WSGLS	J1975WSGLS
Hays	2520CGJ-R			

Table 10	
F.I.P. X METER SWIVEL NUT/COUPLING	
Approved Manufacturers and Models:	
Size	
Manufacturer	$\frac{3}{4}$"
A.Y. McDonald	4654B
Ford Meter Box	BA13232WR
Mueller	B24265-R3
James Jones	J-1966WLS
Hays	2521-R

Table 11		
Ball Corporation Valve		
Approved Manufacturers and Models:		
Manufacturer	CC X CMP	IP X CMP
A.Y. McDonald	4701BQ	4704 BQ
Mueller	B-25008	B-25028
James Jones	1937 SG	1935 SG
Ford Meter Box	FB-1000Q	FB-1100Q

3.6 Gate Valves, Tapping Valves and Tapping Sleeves.

2.6.1. Gate Valves.

2.6.1.1. General Requirements

2.6.1.1.1. Except as otherwise modified or supplemented herein, AWWA Standard C-509-01 or the latest revision thereof, shall govern the design, component materials, construction; manufacture and testing of all resilient seated gate valves. Valves shall be suitable for frequent operation as well as service involving long periods of inactivity. Valves shall be NSF-61 certified.

2.6.1.1.2. Approved manufacturers are shown in Table 12, provided such resilient seat gate valves conform to the provisions contained herein.

Table 12	
APPROVED MANUFACTURER	PRODUCTS LIST
Sizes Three through Twelve Inch	
Manufacturer	Model
American Flow Control	Series 500
Clow Valve Company	2640
Kennedy Valve	Ken-Seal II
M&H Valve Company	4067
Mueller Company	2360 Series Gate Valve
United States Pipe & Foundry Company	Metroseal 250
Sizes Sixteen through Twenty-Four Inch	
Manufacturer	Model
United States Pipe & Foundry Company	Metroseal 250
Mueller Company	2361 Series Gate Valve
Clow Valve Company	2640
American Cast Iron Pipe Co.	2500

- 2.6.1.1.3. The minimum design working water pressure for gate valves with nominal diameters of 3 in., 4 in., 6 in., 8 in., 10 in., and 12 in. shall be 200 psig unless otherwise specified.
- 2.6.1.1.4. The minimum design working water pressure for gate valves with nominal diameters of 16 in., and 20 in. shall be 150 psig unless otherwise specified.
- 2.6.1.1.5. Valves shall be resilient-seated types, bronze mounted with non-rising stems. The closure member shall be fully encapsulated by an elastomer without thin spots or voids. When open the valve shall have a clear, full-port, unobstructed waterway.
- 2.6.1.1.6. Gray iron, ductile iron, steel, brass and bronze materials shall meet or exceed the material requirements of Section 2: Materials of AWWA C-509-01.
- 2.6.1.1.7. Gaskets, O-rings, Coatings, and elastomers shall meet or exceed the material requirements of Section 2: Materials of AWWA C-509-01.
- 2.6.1.1.8. The gate valves shall be designed and constructed for installation in either a horizontal or vertical position. Valves shall be designed for buried installation with stem in the vertical position and shall be furnished for mounting in a horizontal pipeline, unless otherwise specified.
- 2.6.1.1.9. Valve components of brass or bronze shall be manufactured to ASTM recognized alloy specifications of low zinc content bronze, as shown in Table 1 of Section 2.2.4. of ANSI/AWWA Standard C-509-01 or the latest revision thereof. Materials for the stem have minimum yield strength of 40,000 psi. A minimum elongation in 2 inches of 12% and shall be made of bronze per ASTM B763, alloy number UNS C99500. A maximum zinc content of 2% as shown in Table 2 Chemical Requirements of ASTM B763-96 or the latest revision thereof. Stem nut material shall be ASTM B-62 UNS C83600 or ASTM B-584 UNS C84400. The stem shall have a visible external marking at the top to indicate low-zinc, high strength material. The marking shall include a red plastic or neoprene washer placed around the top of the stem under the operating nut.
- 2.6.1.1.10. Valve ends shall be either flanged, tapping valve, mechanical joint, push-on joint or any combination thereof, as specified. All mechanical joint valves shall be supplied with glands, bolts, and gaskets. Valve body bolts and nuts shall meet the strength requirements of ASTM A-307 with dimensions conforming to ANSI B18.2.1. The size of the bolt head shall be equal to the size of the nut and shall be stainless steel in accordance with ASTM 276.
- 2.6.1.1.11. All gate valves shall open left (counter-clockwise), unless otherwise specified.
- 2.6.1.1.12. The following parts of the valve shall be made of either gray or ductile iron: bonnet, body, yoke, wrench nut, O-ring packing plate or seal plate, and gland follower. The gate may be made of gray or ductile iron.
- 2.6.1.1.13. If glands and bushings are used for NRS valves they shall be made of ASTM B-763 bronze UNS C99500. The stem shall be made of cast, forged, or rolled ASTM B-763 bronze UNS C99500. The stem nut material shall be ASTM B-62 bronze UNS C83600 or ASTM B-584 bronze UNS C84400. The gate may be made of bronze ASTM B-763 bronze UNS C99500. Stem seals shall be "O" ring type. The seals shall be designed for dynamic applications.

The design shall be such that the seal above the stem collar can be replaced with the valve under full pressure in the fully open position.

Materials for the "O" ring packing plate shall be in accordance with Section 4.8.3 of the ANSI/AWWA C509-01 Standard or the latest revision thereof.
- 2.6.1.1.14. Enclosed and buried valves shall be coated inside and outside with a fusion bonded epoxy having a nominal 8 mils dry film thickness, which meets or exceeds AWWA C-550-01 and to the maximum extent possible shall be free of holidays. All coatings in contact with the potable water shall be approved for potable water immersion service per ANSI/NSF Standard 61.

- 2.6.1.1.15. The Contractor shall submit three sets of certified drawings showing the principal dimensions, general construction and material specification of the valve proposed. The number of turns to open (close) shall be clearly noted in the valve information. The number of turns to open or close the valve shall be consistent for each valve size for each approved manufacturer.
- 2.6.1.1.16. Valves furnished under this specification shall be supplied from the approved manufacturer list. To be included on the qualified product list, the manufacturer shall provide an Affidavit of Compliance in accordance with the Section 1.5 of the ANSI/AWWA C-509-01 Standard or latest revision thereof. Records of all tests performed in accordance with Section 6.1 and Section 6.2 of the ANSI/AWWA C-509-01 Standard or latest revision thereof will be made available or provided. These records will be representative test results for Section 6.1 and certificate of testing for Section 6.2. An affidavit of testing for the valve assembly as outlined in Section 6.2.2 of the ANSI/AWWA C-509-01 Standard, (350 ft-lbs) will also be provided. A copy of the manufacturer's Quality Assurance Program will be submitted. Blueprints and parts list for the valve shall also be provided.
- 2.6.1.1.17. All gate valve parts shall be designed to withstand the following two pressure requirements, without being structurally damaged. (1) An internal test pressure of twice the rated design working pressure of the valve. (2) The full rated internal working pressure when the closure member is cycled once from a fully open to a fully closed position against the full rated unbalanced working water pressure. In addition to these pressure requirements, the valve assembly and mechanism shall be capable of withstanding an input torque as follows: 200 ft.-lbs. for a 3-in. nominal diameter. 200 ft.-lbs. for a 4-in. nominal diameter. 300 ft.-lbs. for a 6-in. nominal diameter. 300 ft.-lbs. for a 8-in. nominal diameter. 300 ft.-lbs. for a 10- in. nominal diameter. And 300 ft.-lbs. for a 12-in. nominal diameter. For sizes larger than a 12 in. nominal diameter, refer to the manufacturer's specifications.
- 2.6.1.1.18. Resilient seats shall be applied to the gate and shall seat against a corrosion resistant surface. The non-metallic seating surface shall be applied in a manner to withstand the action of line fluids and the operation of the sealing gate under long-term service. A metallic surface shall have a corrosion resistance equivalent to or better than bronze. A non-metallic surface shall be in compliance with ANSI/AWWA C-550. The gate must be fully encapsulated by an elastomer without thin spots or voids. Resilient seats shall be bonded. ASTM D-429 either method A or method B shall prove the method used for bonding or vulcanizing. For method A, the minimum strength shall not be less than 250 psi. For method B, the peel strength shall be 75 lb./in.
- 2.6.1.1.19. Flanged Ends: The end flanges of flanged valves shall conform to dimensions and drillings of ANSI/AWWA C-110/A21.10 or ANSI B-16.1, Class 125.
- 2.6.1.1.20. Mechanical Joint Ends: Mechanical joint bell dimensions shall conform to ANSI/AWWA C-111/A21.11.
- 2.6.1.1.21. Push-on Joints: Push-on joints shall conform to the requirements of ANSI/AWWA C-111/A21.11.
- 2.6.1.1.22. The tapping valves shall be mechanical joints with tapping flange on the other end. The tapping valves shall be furnished complete with glands, bolts, and gaskets. The tapping valve shall have a clear unobstructed waterway.
- 2.6.1.1.23. The seat rings shall be of a large diameter to the permit entry of the full diameter tapping machine cutters. The valve end which mates with the tapping sleeve shall have an alignment lip to fit the recess in the tapping sleeve flange for proper alignment. The lip will be dimensioned in accordance with MSS SP-60 for valves 20-inch nominal pipe size and smaller.
- 2.6.1.1.24. All interchangeable parts shall conform to their required dimensions and shall be free from defects that could prevent proper functioning of the valve. When assembled, valves manufactured in accordance with this standard shall be well fitted and operate smoothly. All like parts of valves of the same model and size produced by the same manufacturer shall be interchangeable.
- 2.6.1.1.25. All castings shall be clean and sound, without defects that will weaken their structure or impair their service. Plugging, welding, or repairing of cosmetic defects is allowed. Repairing of structural defects is not allowed.

Repaired valves shall comply with the testing requirements of this specification after repairs have been made. Repairs within the bolt circle of any flange face are not allowed.

- 2.6.1.1.26. All gate valves shall be hydrostatically tested with twice the specified rated pressure applied to one side of the gate and zero pressure applied to the other side. The test is to be made in each direction across the gate. All tests are to be performed at the manufacturer's plant.
- 2.6.1.1.27. All gate valves shall be operated through a complete cycle in the position for which it was designed to ensure free and proper functioning of all parts in the intended manner. Any defects in workmanship shall be corrected and the test repeated until satisfactory performance is demonstrated. All tests are to be performed at the manufacturer's plant.
- 2.6.1.1.28. A hydrostatic test pressure equal to twice the rated working pressure of the valve shall be applied to all assembled valves with the gates in the open position. The test shall show no leakage through the metal, pressure containing joints, or stem seals. All tests are to be performed at the manufacturer's plant.
- 2.6.1.1.29. A test shall be made from each direction at rated working pressure to prove the sealing ability of each valve from both directions of flow. The test shall show no leakage through the metal, pressure containing joints, or past the seat. All tests are to be performed at the manufacturer's plant.
- 2.6.1.1.30. Markings shall be cast on the bonnet or body of each valve and shall show the manufacturer's name or mark, the year the valve casting was made, the size of the valve, and the designation of working water pressure, for example "200 W".
- 2.6.1.1.31. The Engineer may, at no cost to the Contractor, subject random valves to testing by an independent laboratory for compliance with these standards. Any visible defect or failure to meet the quality standards herein will be grounds for rejecting the entire order.
- 2.6.1.1.32. Table 12 identifies specified manufacturers that are approved.
- 2.6.1.2. Workmanship
 - 2.6.1.2.1. All parts of the resilient seat gate valve shall be designed and manufactured to the tolerances specified in ANSI/AWWA C-509-01 or latest revision thereof and this specification.
 - 2.6.1.2.2. All parts of the resilient seat gate valve manufactured by a given manufacturer shall be interchangeable with like parts from another resilient seat gate valve of the same model and size and by the same manufacturer.
 - 2.6.1.2.3. All interchangeable parts shall conform to their required dimensions and shall be free from defects that could prevent proper functioning of the valve.
 - 2.6.1.2.4. All castings shall be clean and sound, without defects that will weaken their structure or impair their service. Plugging, welding, or repairing of cosmetic defects is allowed. Repairing of structural defects is not allowed. Repaired valves shall comply with the testing requirements of this specification after repairs have been made. Repairs within the bolt circle of any flange face are not allowed.
 - 2.6.1.2.5. The resilient seat gate valves shall be well fitted.
 - 2.6.1.2.6. Operation of the resilient seat gate valve shall be smooth.
 - 2.6.1.2.7. All parts shall be free of structural defects.
 - 2.6.1.2.8. The resilient seat gate valve shall be watertight.
- 2.6.1.3. Painting

- 2.6.1.3.1. All exterior and interior surfaces of the valve shall be coated with epoxy, N.S.F. 61 certified. The epoxy shall have a nominal dry film thickness of 8 mils, and shall be in accordance with AWWA C-550, latest revision.
- 2.6.1.3.2. Coating shall be as close to holiday free as is technologically possible.
- 2.6.1.4. Testing
 - 2.6.1.4.1. Hydrostatic Test: Hydrostatic Test shall be performed on the valve in accordance with Section 6.1 Proof of Design Testing of ANSI/AWWA C-509-01 or latest revision thereof.
 - 2.6.1.4.2. Torque Test: Torque Test for prototype valves shall be performed on the valve in accordance with Section 6.1 Proof of Design Testing of ANSI/AWWA C-509-01 or latest revision thereof.
 - 2.6.1.4.3. Leakage Test: Leakage Test shall be performed on the valve in accordance with Section 6.1 Proof of Design Testing of ANSI/AWWA C-509-01 or latest revision thereof.
 - 2.6.1.4.4. Pressure Test: Pressure Test shall be performed on the valve in accordance with Section 6.1 Proof of Design Testing of ANSI/AWWA C-509-01 or latest revision thereof.
 - 2.6.1.4.5. Operation Test: Operation Test shall be performed on the valve in accordance with Section 6.2 Production Testing of ANSI/AWWA C-509-01 or latest revision thereof.
 - 2.6.1.4.6. Shell Test: Shell Test shall be performed on the valve in accordance with Section 6.2 Production Testing of ANSI/AWWA C-509-01 or latest revision thereof.
 - 2.6.1.4.7. Seat Test: Seat Test shall be performed on the valve in accordance with Section 6.2 Production Testing of ANSI/AWWA C-509-01 or latest revision thereof.
 - 2.6.1.4.8. An Affidavit of Compliance certifying that all required tests have been performed shall be provided in accordance with Section 6.3 Affidavit of Compliance of ANSI/AWWA C-509-01.
 - 2.6.1.4.9. The Affidavit of Compliance, the results of ASTM testing procedures and requirements for materials, Manufacturer's Quality Assurance Program, and the records of all tests performed on the valve shall be kept and provided by the supplier/manufacturer in a single hard cover bound notebook with the bid or with the shipping documents and shall be approved by the Engineer.
- 2.6.1.5. Quality Assurance
 - 2.6.1.6. Manufacturers shall have an ASME or I.S.O. 9001 registered commercial quality system. Noncompliance to this registered commercial quality system requirement will result in removal of the manufacturer's product from the approved manufacturer's list shown in Table 12 of this specification. If on receipt of resilient seat gate valves they are found to be non-compliant the Contractor shall replace the defective resilient seat gate valves according to resilient seat gate valve size with a resilient seat gate valve that meets these specifications at no cost to the Department..
- 2.6.1.7. References
 - 2.6.1.7.1. American National Standards Institute and American Water Works Association Standard C-509-01 (ANSI/AWWA C-509-01).
 - 2.6.1.7.2. Manufacturers Standardization Society MSS SP-60.
- 2.6.2. Tapping Valves and Tapping Sleeves.
 - 2.6.2.1. Tapping Sleeves

Band shall conform to the minimum OD size ranges and lengths specified in this specification. The flange shall be manufactured in compliance with AWWA C-223.07, Class D ANSI B.16.1 drilling, recessed for tapping valves MSS_SP60. Mechanical Joint tapping sleeve outlet shall meet or exceed all material specifications as listed below and be suitable for use with standard mechanical joint resilient wedge gate valves per AWWA C-509-94.

2.6.2.1.1. General Requirements

2.6.2.1.1.1. Tapping sleeves 4 inch – 12 inch:

Entire fitting to be stainless steel type 304 (18-8). The body, lug and gasket armor plate to be in compliance with ASTM A-240. The flange shall be cast stainless steel in compliance with ASTM A-743. The MJ outlet shall be one-piece casting made of stainless steel.

The test plug shall be $\frac{3}{4}$ " NTP in compliance with ANSI B2.1 and shall be lubricated or coated to prevent galling. All metal surfaces shall be passivated after fabrication in compliance with ASTM A-380.

The gasket is to provide a 360-sealing surface of such size and shape to provide an adequate compressive force against the pipe after assembly, to affect a positive seal under combinations of joint and gasket tolerances. The materials used shall be vulcanized natural or synthetic rubber with antioxidant ingredients to resist set after installation. No reclaimed rubber shall be used. A heavy-gauge-type 304-stainless armor plate shall be vulcanized into the gasket to span the lug area.

Lugs are to be heliarc welded (GMAW) to the shell. Lug shall have a pass-through-bolt design to avoid alignment problems and allow tightening from either side of the main. Bolts shall not be integrally welded to the sleeve. Finger Lug designs are not approved; it is the intent of these specifications to allow tapping sleeve that has a lug design similar to the approved models.

Bolts and nuts shall be type 304 (18-8) stainless steel and lubricated or Teflon coated to prevent galling or seizing. Bent or damaged unit will be rejected.

Quality control procedures shall be employed to insure that the shell, Lug, (4" and larger nominal pipe diameter) armor plate, gasket and related hardware are manufactured to be free of any visible defects. Each unit, after proper installation, shall have a working pressure rating up to 200 psi, and a test pressure of 250 psi.

The sleeve construction shall provide a positive means of preventing gasket cold flow and/or extrusion.

Each sleeve shall be stenciled, coded or marked in a satisfactory manner to identify the size range. The markings shall be permanent type, water resistant that will not smear or become illegible.

2.6.2.1.1.2. Tapping Sleeves 16 inch and large nominal pipe diameter:

The body shall be in compliance with ASTM A-285 Grade C or ASTM A-36. Test plug shall be $\frac{3}{4}$ " NPT conforming to ANSI B2.1.

The gasket is to provide a watertight sealing surface of such size and shape to provide an adequate compressive force against the pipe. After assembly, the gasket will insure a positive seal under all combinations of joint and gasket tolerances. Gasket shall be formed from vulcanized natural or synthetic rubber with antioxidants ingredients to resist set after installation. No reclaimed rubber shall be used. Bolts and nuts shall be type high strength, corrosion resistant, low alloy per AWWA C-111, ANSA A21.11

Quality control procedures shall be employed to insure that the shell, gasket and related hardware are manufactured to be free of any visible defects. Each unit, after proper installation, shall have a working pressure rating up to 150 psi, and a test pressure of 200 psi.

Unless otherwise noted, unit shall be protected by fusion Epoxy 8-10 mil line and coat per AWWA C-213.

Units for concrete steel cylinder pipe shall be furnished with load bearing set screws on the gland flange to transfer loads on the outlet away from the steel cylinder and onto the sleeve. Epoxy-coated tapping sleeves do not require grout seal cavity. (AWWA Manual of Practice M-9)

Each sleeve shall be stenciled, coded or marked in a satisfactory manner to identify the size range. The markings shall be permanent type, water resistant that will not smear or become illegible.

2.6.2.1.2. Standard Ranges

Table 13			
Nominal Dia (in) x Min Length (in)	Flange Outlet (in)	Range	Min OD Range (in)**
4 x 16	4	A	4.75 – 4.95
		B	4.90 – 5.10
6 x 16	4	A	6.70 – 7.10
		B	7.00 – 7.40
		C	7.35 – 7.75
6 x 16	6	A	6.80 – 7.15
		B	7.05 – 7.40
		C	7.40 – 7.75
8 x 16	4 & 6	A	9.00 – 9.45
		B	9.35 – 9.70
		C	9.70 – 10.00
8 x 20	8	A	9.00 – 9.35
		B	9.35 – 9.70
		C	9.70 – 10.00
10 x 16	4 & 6	A	11.03 – 11.47
10 x 20	8	B	11.60 – 12.00
10 x 24	10		
12 x 16	4 & 6	A	13.00 – 13.40
12 x 20	8	B	13.40 – 13.80
12 x 24	10	C	14.10 – 14.50
12 x 32	12		
16 x 12	4 & 6		17.33 – 17.87
16 x 16	8		18.62 – 19.19
16 x 20	10		
16 x 24	12		
16x 36	16*		
20 x 12	4 & 6	A	21.51 – 22.15
20 x 16	8	B	23.46 – 24.16
20 x 20	10		
20 x 24	12		
20x 36	16*		
20 x 40	20*		
24 x 12	4 & 6	A	25.71 – 26.41
24 x 16	8	B	28.14 – 28.84
24 x 20	10		
24 x 24	12		
24 x 36	16*		
24 x 40	20*		
24 x 48	24*		
30 x 12	4 & 6	A	29.78 - 30.48
30 x 16	8	B	31.52 – 32.22
30 x 20	10		
30 x 24	12		
30 x 36	16*		
30 x 40	20*		
30 x 48	24 x 30*		

*Range to be specified when ordered

**Ranges may be broadened by not narrowed. For concrete steel cylinder pipe the OD of the pipe and cylinder shall be supplied with the order.

For pipe larger than 30 inches nominal diameter, tapping sleeves shall be custom fabricated to fit non standard ranges, in conformance with the intent of these specifications.

The Engineer may, at no cost to the Contractor, subject random units to testing by an independent laboratory for compliance with these standards. Any visible defect of failure to meet the quality standards herein will be ground for rejecting the entire order.

Table 14 lists identified specific manufactured items by catalog number that are approved:

Table 14		
Manufacturer	Model	Size Range (in)
JCM Industries	#432	4 - 12
	#412	16 and larger
Power Seal	#3490AS or 3490MJSS	4 - 12
	3490MJSS	16 and larger
Romac Industries	SST III	4 - 12
	SST III	16 and larger
Ford Meter Box	FTSS	4 - 12
	FTS	16 and larger
Dresser	Style 610/630	4 - 12
	Style 610/630	16 and larger
Cascade	CST-1	4 - 12
Smith Blair	#622	16 and larger

3.7

Butterfly Valves (150 or 250 PSI Class).

This covers Class 150 PSI, 3 inches through 72 inches, and Class 250 PSI, 4 inches through 54 inches, rubber-seated butterfly valves. All products furnished shall be in conformance with the American National Standards Institute and American Water Works Association C504 (ANSI/AWWA C504) or latest revision thereof; however, the body construction of the valve shall exceed the ANSI/AWWA C504 by the values specified herein. All coatings in contact with potable water shall be certified to N.S.F. 61. A proof of design certification shall be provided upon request.

2.7.1.

Definitions

All definitions are defined according to ANSI/AWWA C504.

2.7.1.1.

Actuator: A device attached to the valve for the purpose of rotating the valve disc to an open, closed, or intermediate position; preventing disc over-travel; and maintaining the disc in any position.

2.7.1.2.

Butterfly Valve: A valve that uses a disc rotatable through an angle of approximately 90 degrees as a closure member. The valve is closed when the disc is perpendicular to the flow way, open when parallel to the flow way, or used for throttling when positioned between open and closed.

2.7.1.3.

Disc: The closure member that is positioned in the flow stream to permit flow or to obstruct flow (depending on closure position) and that rotates through an angle of 90 degrees from full open to full shutoff.

2.7.1.4.

Rubber Seat: A rubber ring around the inside of the valve body to affect a seal against the metal seating surface when the disc is closed. Or resilient seats shall be located on the valve disc and shall provide a 360 degrees continuous, uninterrupted seating surface. Seats shall be mechanically retained with a stainless steel retaining ring and stainless steel Nylok cap screws, or an approved equal, which shall pass through both the resilient seat and the retaining ring.

The resilient seat's mating surface shall be to a 360 degrees continuous, uninterrupted stainless steel body seat ring. The retaining ring shall be continuous or investment cast with overlapping sections serrated grooves, and shoulders. Resilient seats shall be field adjustable and replaceable and shall not require hypodermic needles or pressure vessels to replace or adjust.

2.7.2. General Requirements

2.7.2.1. Except as otherwise modified or supplemented herein, AWWA Standard C504 or the latest revision thereof, shall govern the design, component material construction, manufacture and testing of all butterfly valves.

2.7.2.2. Valves shall be Class 150 PSI or Class 250 PSI of the short-body type with a bi-directional shut-off rating, a hydrostatic body shell test and a maximum upstream line velocity rating according to the table listed below unless specified otherwise.

Valve Class	Bi-directional Shut-off Rating	Hydrostatic Body Shell Test	Diameter	Velocity
150 PSI	150 psig	300 psig	3 inch through 20 inch	16 feet per second
150 PSI	150 psig	300 psig	24 inch through 72 inch	8 feet per second
250 PSI	250 psig	500 psig	4 inch through 20 inch	16 feet per second
250 PSI	250 psig	500 psig	24 inch through 54 inch	8 feet per second

2.7.2.3. Valve shall be in the same alignment as a horizontal pipe and shall be for buried service, unless otherwise specified. Valve shall be configured with a horizontal valve shaft and a vertical actuator shaft with standard 2" AWWA operating nut. The actuator shall be side mounted.

2.7.2.4. Valve body shall be of cast iron conforming to ASTM Specification A-26, Class B. Class 250 will also allow the use of Ductile Iron conforming to ASTM A536, grade 65-45-12.

2.7.2.5. Class 150 valve body ends shall be flat-faced flanged in accordance with ANSI B16.1, Class 125. All valves shall conform to AWWA C504, Table 2 of Section 3.1 Valve Bodies, laying lengths for flanged valves and minimum body shell thickness for all body types.

2.7.2.6. Class 250 valve body ends shall be flat-faced flanged in accordance with ANSI B16.1, Class 250. All cast iron valves shall exceed minimum body shell thickness AWWA C504 Class 150B, Table 2 of Section 3.1 Valve Bodies,

2.7.2.6.1. Laying lengths for flanged and wafer valves and minimum body shell thickness for all body types by the following: Sizes 4" through 10" - 15% or greater, Sizes 12" through 24" - 20% or greater, and Sizes 30" through 54" - 50% or greater. Ductile iron valve body thicknesses shall conform to the table below. Ductile iron and cast iron laying lengths shall be as specified in the table below unless otherwise specified.

Ductile Iron Valve Diameter Inch	Ductile Iron Thickness Inch Laying	Ductile Iron Lengths Inch
3	.27	5
4	.40	5
6	.43	5
8	.46	6
10	.54	8
12	.58	8
14	.63	8
16	.68	8
18	.79	8
20	.83	8
24	.93	8
30	1.10	12
36	1.22	12
42	1.35	12
48	1.48	15
54	1.63	15
60	1.89	15
66	2.00	18
72	2.375	18

Valve Diameter Cast Iron	Thickness Cast Iron	Laying Length Cast Iron Inch
6 Inch	Per specification	6
8 Inch through 12 inch	Per specification	8
14 Inch through 30 inch	Per specification	12
36 Inch through 54 Inch	Per specification	15

- 2.7.2.7. Valve shall be of such design that the disc will seat at 90 degrees with the pipe axis.
- 2.7.2.8. Valve shall be of such design that the disc will not flutter or vibrate when operated in a throttled position.
- 2.7.2.9. Valves disc shall be of Cast Iron A-48, class 40 Cast Iron A-126, class B or Ductile Iron ASTM A-536, grade 65-45-12 and shall be of disc design to provide 360 degree uninterrupted seating.
- 2.7.2.10. The valve seat shall be natural or synthetic rubber applied integrally to the body or disc. For valves 24 inches or larger, the rubber seat shall be capable of mechanical adjustment in the field and shall be field replaceable. Special tools required for seat adjustment shall be provided with the valve. Special tools required for seat replacement shall be furnished with the replacement seat. Mechanical adjustment or attachment of the seat and seat ring does not include welding. The mating seat surface shall be type 304 or type 316 stainless steel, ni-chrome or monel. Sprayed or plate mating seat surfaces are not acceptable.
- 2.7.2.11. Class 150 psi Valve shafts shall be type 304 stainless steel conforming to ASTM A-276, and Class 250 psi Valve shafts shall be type 630 stainless steel conforming to ASTM A-564 condition H-1100. Both shall have a diameter equal to or greater than that shown for Class 150B in Table 3 of AWWA C504. Shafts shall conform to the requirements of Section 3.3, Valves Shaft of AWWA C504 for one-piece or stub shaft types. Connection between the shaft and disc shall be dowel, taper pins, or torque plugs, which are mechanically secured.
- 2.7.2.12. The valve assembly shall be furnished with a factory-set, non-adjustable disc shaft thrust bearing that insures the valve disc is centered within the valve body seat at all times.
- 2.7.2.13. Valve shaft bearings shall be permanent, self-lubricated, bearings, which provides continuous, low-friction maintenance-free operation. Shaft bearing shall be contained in integral hubs of the valve body.

- 2.7.2.14. Valve shaft seal shall consist of O-ring, V-type, or U-cup type packing where the shaft projects through the valve body for the actuator connection.
- 2.7.2.15. The valve shall be provided with a fully enclosed, permanently lubricated actuator of the traveling nut or worm gear design. The actuator shall be connected to the valve shaft by means of a key and keyway connection.
- 2.7.2.16. All actuators shall have adjustable, mechanical stop limits in accordance with AWWA C504 Section 3.8.2. All Class 150 psi and 4" through 54" Class 250 psi valve actuators shall be capable of withstanding 450 ft-lbs of input torque against the open or closed stops without damage.
- 2.7.2.17. Valves for below ground applications shall be provided with an AWWA wrench nut. The wrench nut shall have an arrow cast thereon, indicating the direction on of opening. The wrench nut shall be suitably fastened to the actuator input shaft. If the shaft is smooth, the wrench nut shall be fastened to the input shaft by means of a minimum 5/16" diameter steel pin passing entirely through the shaft and the wrench nut. Key with keyway will be acceptable. If the shaft is splined, the wrench nut shall be formed to fit the splined shaft. The actuator shall be designed to produce the specified torque with a maximum input of 150 ft-lbs applied to the wrench nut.
- 2.7.2.18. Valves for aboveground applications shall be provided with a handwheel. The handwheel shall have an arrow thereon, indicating the direction of the opening. The handwheel shall be suitably fastened to the actuator input shaft. Actuators equipped with handwheels shall be designed to produce the specified torque with a maximum pull of 80 pounds of the handwheel rim.
- 2.7.2.19. The requirement for either wrench nut or handwheel and the direction of opening will be specified on each purchase order.
- 2.7.2.20. Valves shall open on left turn (counter-clockwise).
- 2.7.2.21. The Contractor shall supply, with his valve material submittal, three sets of certified drawings showing the principal dimensions, general construction and material specification of the valve proposed. The number of turns to open (close) shall be clearly noted in the valve information submitted with the proposal documents.
- 2.7.2.22. The supplier/manufacture shall provide Affidavit of Compliance with applicable sections of AWWA C504 to include the following: Results of ASTM testing procedures and requirements for materials will be provided to the Engineer upon request, Manufacturer's Quality Assurance Program, leak-tightness testing and proof of design testing of representative actuators in accordance with AWWA C504 Section 3.8.5.2 as modified herein (450 ft.-lbs.). Compliance assurance will be required in accordance with AWWA C504 Section 5.1.2, Affidavits. Results of performance tests, proof of design test, AWWA C504 Section 5.2.4, hydrostatic test, leakage test, and Affidavit of Compliance shall be provided with the material submittal or with the shipping documents and shall be approved by the Engineer.
- 2.7.2.23. Valves furnished under this specification shall be supplied by our approved manufacturer list.
- 2.7.3. Workmanship
- 2.7.3.1. All parts of the butterfly valve shall be designed and manufactured to the tolerances specified in ANSI/AWWA C509 or latest revision thereof and this specification.
- 2.7.3.2. All parts of the butterfly valve manufactured by a given manufacturer shall be interchangeable with like parts from another butterfly valve of the same model and size and by the same manufacturer.
- 2.7.4. Painting

- 2.7.4.1. All interior and exterior ferrous surfaces of the valve, including the disc, shall be coated with epoxy, N.S.F. 61 certified. The epoxy shall have a nominal thickness of 8 mils, and shall be in accordance with AWWA C550, latest revision.
- 2.7.4.2. Coating shall be as close to holiday free as is technologically possible.
- 2.7.5. Testing and Inspection
 - 2.7.5.1. Performance Tests: Performance tests shall be performed on each valve in accordance with Section 5.2.1 Testing of ANSI/AWWA C504 or latest revision thereof.
 - 2.7.5.2. Leakage Tests: Leakage tests shall be performed on each valve in accordance with Section 5.2.2 Testing of ANSI/AWWA C504 or latest revision thereof and at an operating pressure of 250 psig.
 - 2.7.5.3. Hydrostatic Tests: Hydrostatic tests shall be performed on each valve in accordance with Section 5.2.3 Testing of ANSI/AWWA C504 or latest revision thereof, and at a maximum operating pressure of 500 psig for Class 250 valves.
 - 2.7.5.4. Proof-of-Design Tests: Proof-of-Design tests shall be performed on each valve in accordance with Section 5.2.4 Testing of ANSI/AWWA C504 or latest revision thereof.
 - 2.7.5.5. An Affidavit of Compliance certifying that all required tests have been performed shall be provided.
 - 2.7.5.6. The Affidavit of Compliance and the records of all tests performed on the valves shall be kept and provided in a single hard cover bound notebook.
- 2.7.6. Quality Assurance
 - 2.7.6.1. Manufacturers shall have an ASME or I.S.O. 9001 registered commercial quality system. If on receipt of butterfly valves they are found to be non-compliant the Contractor shall replace the defective butterfly valves according to butterfly valve size with a butterfly valve that meets the Water System Utility Owner's specifications. The defective butterfly valves will be returned to the manufacturer, freight collect, and the manufacturer shall replace the butterfly valve, freight prepaid.

If Water System Utility Owner audits, product inspection and performance data review, in accordance with these specifications, determine excessive butterfly valve non-compliance, the manufacturer will be subject to removal from the approved manufacturer's list. If the butterfly valve becomes defective during the manufacturer's specified warranty period, a Water System Utility Owner quality assurance and manufacturer review will ensue. If the review determines manufacturing non-conformance the Contractor shall replace the butterfly valve according to size with a butterfly valve that meets these specifications at no cost to the Department or Owner.
- 2.7.7. References
 - 2.7.7.1. American National Standards Institute and American Water Works Association Standard C504 (ANSI/AWWA C504).

APPROVED MANUFACTURER and PRODUCTS LIST

Manufacturer	Product	
	Class 250 psi	Class 150 psi
Mueller	Linseal XP	Linseal III
Henry Pratt (above ground)	HP-250	2F II (3" thru 20") and XR-70 (24" thru 72")
Henry Pratt (below ground)	HP-250	Ground hog (3" thru 72")
DeZurik	BAW	BAW
CMB Industries, Inc.	K-Flo Model 504 and K-Flo Model 47	K-Flo Model 504 and K-Flo Model 47
Val-Matic	Series 2000	Series 2000

3.8

Valve Boxes.

All valve box assemblies are to conform to the details shown on the plans. Each valve box assembly is to be of cast-iron and is to consist of a base, top section, and lid.

Valve boxes are to be of a single size with a nominal diameter of 6-inches.

The valve box lid is to be labeled "water" and is to be so designed so that it will remain firmly seated in place when subjected to vehicular traffic.

The valve box assembly is to be of sufficient toughness and strength to withstand impact loads and shock resulting from vehicular traffic.

The valve box assembly is to be coated with a standard bituminous coating of either coal tar or asphalt base applied to all inside and outside surfaces.

3.9

Meter Boxes.

For non-traffic bearing locations, the meter box assembly for 5/8-in. through 1-in. meters box and lid is to be black and constructed out of modified polyethylene material for maximum durability and corrosion resistance. The black material is for maximum UV protection and shall be uniform throughout meter box and lid for maximum longevity and not have a foaming agent that creates air pockets within the plastic wall. The body and lid shall withstand a 20,500 lb loading in a non-deliberate and incidental traffic. Plastic Lid is to have the following:

6. "Water Meter" and "{Utility Owners Name}" molded into the lid,
7. seat securely and evenly inside the meter box and shall not overlap the top edge of the meter box,
8. "Overlap" and securely and evenly on the existing cast iron meter box with like dimensions,
9. a diamond pattern for skid resistance and an AMR Slide Mount molded into the lid on the underneath side and off center for placement for an AMR transponder, if specified in the plans, to help in the protection of the radio antenna,
10. a brass worm gear lock that will secure the existing cast iron meter box of like dimensions and secure the plastic meter box,
11. a molded receptacle for placement of key, and
12. one (1) piece of 1/2" rebar secured in lid.

Plastic body is to have the following:

13. a crush resistant ribbing along the outside of box,
14. a flange around the top opening to help prevent setting and aide in adjustment to grade, and
15. designed to accommodate all plastic lids.

For traffic bearing locations, the meter box assembly for 5/8-in. through 2-in. meters is to consist of cast-iron rectangular boxes box and a steel checkered plate rectangular with raised lug pattern as shown on the plans.

The castings are to be dipped in coal tar at a temperature of 350°F and the metal is to be at a temperature of 300°F prior to dipping. The casting is to be dipped and cured independently and the coating is to have ceased to be "tacky" within 72 hours after dipping.

The steel checkered plate rectangular cover is to be hot dip galvanized after fabrication.

The meter box is to have an ultimate tensile strength of 25,000 psi and is not to be brittle.

The casting is to have an "as cast" clean smooth surface and be free from internal porosity; castings that are made smooth by grinding are unacceptable.

Quality Assurance: If on receipt of meter box(es) or lid(s) they are found to be non-compliant, the Contractor is to replace defective product at no cost to the Department and/or the Water System Utility Owner. Any visible defect of failure to meet specification will be grounds for rejecting entire order.

Approved Plastic Meter Box and Lid Manufacturer (or equal):

DFW Plastics Inc. Model Numbers:

16. D-1218-RWSBSM-Complete box

17. D-1218-RWSBSM-lid

18. D-1218 – body

3.10

Fire Hydrants.

2.10.1. General Requirements

2.10.1.1. The Engineer reserves the right to limit the purchase of fire hydrants from manufacturers and to the models specified, as shown on Table 15, provided such fire hydrants conform to the provision contained herein.

2.10.1.2. Each hydrant shall be designed for a minimum working pressure of 200 psig.

2.10.1.3. All parts of the hydrant shall be designed to withstand, without being functionally impaired or structurally damaged, a hydrostatic test of not less than 400 psig or twice the rated working pressure, whichever is greater, with the hydrant completely assembled and pressurized as follows:

2.10.1.3.1. With the nozzle caps in place, the main valve open, the hydrant inlet capped, and the test pressure applied to the interior of the hydrant.

2.10.1.3.2. With the main valve closed, the hydrant inlet capped, and the test pressure applied at the hydrant inlet.

2.10.1.3.3. The design safety factor of the operating mechanism shall not be less than 5 and shall be based on the foot-pounds of torque required for the closing and opening of the hydrant at a working pressure of 200 psig. Hydrants shall be functional and capable of being opened or closed without difficulty following an application of an operating torque of 200 lbf-ft at the operating nut in the opening direction with the hydrant fully opened and the closing direction with the hydrant fully closed. The torque requirements apply only to hydrants of 5-foot bury or less.

2.10.1.4. The length of bury shall be as specified.

2.10.1.5. The fire hydrant shall have 2 hose nozzles and 1 pumper nozzle.

2.10.1.6. The nominal inside diameter of the hose nozzle shall be 2 ½ inches.

2.10.1.7. The nominal inside diameter for the pumper nozzle shall be 4 inches.

- 2.10.1.8. The outlet-nozzle threads are to conform to the National Fire Protection Association (NFPA) 2003, Standard for Fire Hose Connections.
- 2.10.1.9. The nominal diameter of the main valve opening shall be 5 ¼ inches.
- 2.10.1.10. The hydrant shoe shall be provided with a 6 inches mechanical joint connection to fit the connecting pipe.
- 2.10.1.11. The fire hydrant shall open on left turn (counter-clockwise).
- 2.10.1.12. The color of the finish paint above the ground line shall be red.
- 2.10.1.13. The fire hydrant shall have a non-rising stem.
- 2.10.1.14. No more than one 6" stem extension shall be provided if required to make the base of the fire hydrant grade level.
- 2.10.1.15. The bonnet section shall be designed so all bearing surfaces and stem threads are sealed in a lubricant reservoir. If oil is used as a lubricant, the reservoir shall be designed to allow for easy filling through a fitting or plug. Where grease is used as a lubricant, the reservoir will be sealed. The reservoir will be adequately sealed with "O" rings or other suitable sealing system approved by the Engineer.
- 2.10.1.16. The fire hydrant shall have a safety flange or breakaway flange at the ground line as stipulated in Section 3.1 General Design of ANSI/AWWA C-502-05 or latest revision thereof.
- 2.10.1.17. Fire hydrant nozzle cap chains shall be required and shall be attached permanently to the fire hydrant as stipulated in Section 3.2 Detailed Design of ANSI/AWWA C-502-05 or latest revision thereof.
- 2.10.1.18. Parts that require lubrication and come into contact with water shall be lubricated with a non-toxic food grade lubricant that does not pose a health hazard to the public if consumed.
- 2.10.2. Workmanship
 - 2.10.2.1. All foundry and machine work shall be performed in accordance with good standard practice for the class of work involved and in conformance with accepted drawings, if required. When assembled, hydrants manufactured in accordance with this specification shall be well fitted and shall operate smoothly. The body and shaft shall be watertight.
 - 2.10.2.2. All parts shall conform to the required dimensions and shall be free from defects that could prevent proper functioning of the hydrant.
 - 2.10.2.3. All castings shall be clean and sound without defects that will weaken their structure or impair their service.
- 2.10.3. Paint
 - 2.10.3.1. The exterior surface of the hydrant shall be coated with a coating that shall meet or exceed the requirements of Federal Specification TT-C-494b. A second coat of water based or oil based enamel paint aluminum in color will then be applied from the top of the hydrant to a point 18 to 20 inches below the center line of the pumper nozzle or down to the traffic safety flange connection at the ground line.
 - 2.10.3.2. All interior surfaces, machined surfaces, such as the threaded portion of the stem or stem nut, which must fit closely with the adjacent parts, shall be coated with a coating that shall meet or exceed Federal Specification TT-C-494b. Stem surfaces contained within a lubricant reservoir and not in contact with potable water may be free of coating.
 - 2.10.3.3. The interior and exterior of the hydrant shoe shall be coated with a fusion-bonded epoxy having a nominal dry film thickness of 8 mils, conforming to ANSI/AWWA C-550-05, and certified to NSF 61.

- 2.10.3.4. Coating shall be as close to holiday free as is technologically possible.
- 2.10.4. Testing and Inspection
 - 2.10.4.1. Each assembled hydrant shall be subjected to two shop tests under a hydrostatic pressure of 400 psig or twice the rated working pressure, whichever is greater. One test shall be made with the entire interior of the hydrant under pressure and another test made with the main valve closed and the base under pressure from the inlet side. Under the test procedure, there shall be no leakage through the main valve or seals or through the castings or the joints of the assembled hydrant. Under the test conditions, the leakage through the drain valves shall not exceed 5 fl oz/min. Other leakage or other imperfections found in either test shall be corrected or the hydrant retested. The tests shall be conducted for a sufficient time to allow a check of all points of possible leakage and for a minimum of 30 seconds after all air has been exhausted.
 - 2.10.4.2. Each assembled hydrant shall be operated through a full open-close cycle when not under pressure. The torque required for performing this operation shall not exceed 200 lbf-ft.
 - 2.10.4.3. All fire hydrant tests and inspections shall conform to ANSI/AWWA C-502 Section 5.1 Production Testing, ANSI/AWWA C-502 Section 5.2 Prototype Testing, and ANSI/AWWA C-502-05 Section 5.3 Inspection and Rejection.
 - 2.10.4.4. The manufacturer shall provide an Affidavit of Compliance conforming to Section 1.7 Affidavit of Compliance of ANSI/AWWA C-502-05 or latest revision thereof.
- 2.10.5. Quality Assurance
 - 2.10.5.1. Manufacturers shall have an ASME or I.S.O. 9001 registered commercial quality system. Noncompliance to this registered commercial quality system requirement will result in removal of the manufacturer's product from the approved manufacturer's list shown in Table 15 of this specification. Fire hydrants, found to be noncompliant, shall be replaced, by the Contractor, with a fire hydrant that meets this specification, according to the hydrant size, at no cost to the Department or Owner.

APPROVED FIRE HYDRANT MAINTENANCE KITS

The Water System Utility Owner will attempt to use fire hydrant maintenance kits in the approved hydrants. Table 16 of this specification provides the product model numbers.

- 2.10.6. References
 - 2.10.6.1. American National Standards Institute and American Water Works Association Standard C-502-05 (ANSI/AWWA C-502-05).
 - 2.10.6.2. American National Standards Institute and American Water Works Association Standard C-550-05 (ANSI/AWWA C-550-05).

APPROVED MANUFACTURERS

The manufacturers listed in Table 15 are approved.

Table 15	
Manufacturer	Model
American Darling	B84B 5-1/4" (w / metal weather cap)
Clow Valve Company	Medallion
Kennedy Valve Company	Guardian
M & H Valve Company	Reliant Model 929
Mueller Company	Super Centurion 250
United States Pipe and Foundry, Inc.	Metropolitan
Waterous	Pacer 100
American AVK Company	Model 2780

The fire hydrant maintenance kits listed are the reference product model numbers.

Table 16	
Manufacturer	Model
American Darling	B84B 5-1/4" (w / metal weather cap)
Clow Valve Company	Medallion
Kennedy Valve Company	Guardian
M & H Valve Company	Reliant Model 929
Mueller Company	Super Centurion 250
United States Pipe and Foundry, Inc.	Metropolitan
Waterous	Pacer 100
American AVK Company	Model 2780 Dry

3.11

Polyethylene Wrapping Material.

2.11.1.

Polyethylene wrapping material is to be used to encapsulate all ductile and cast-iron pipe.

Polyethylene wrapping for ductile and cast iron water mains is to consist of a 4 mil tubular section of cross-laminated high-density polyethylene, which has a high dielectric and tensile strength, for use in insulating cast-iron and ductile-iron pipe from the electrolytic action encountered in highly active soils.

Polyethylene wrapping is to consist of opaque cross-laminated high-density polyethylene sheet continuously thermally bonded to form a tubular section. The tubes may be supplied in bulk length on rolls or in individual pre-cut lengths. See Table 17 for size and length chart, in accordance with AWWA C-105 (Table 1) for minimum requirements. When supplied in specific pipe lengths, the tubes are to contain a minimum of 4-ft. over the actual pipe length to allow for overlap.

The polyvinyl sheet of film for the tubular wrapping is to be of virgin resins meeting raw and physical properties of ASTM D-1248 and AWWA C-105, latest edition. The material is to be 4 mil cross-laminated high-density polyethylene of uniform film thickness and be free of imperfections such as pin holes, etc., after being thermally seamed into tubular form. The finished product will have a nominal thickness of 4 mils, with tolerances of minus ten percent.

The material is to have no volatile constituents, the loss of which may affect ductility. The material is also to have the following properties:

Mechanical: The polyethylene film is to have a tensile strength per latest ASTM D-882 test, of 6300 psi min. The film is to have an elongation of not less than 100% of the test strip per latest ASTM D-882 test. The film is to have an impact resistance 800 gram min per (ASTM D-1709 Method B). The film is to have a propagation tear resistance of 250 gf minimum in machine and transverse direction (ASTM D1922).

Dielectric: The film is to have a dielectric strength of 800 volts per mil thickness per ASTM D-149.

Marking Requirements

The polyethylene film supplied shall be clearly marked, at a minimum of every 2-ft along its length, containing the following information.

19. Manufacturer's name or trademark
20. Year of manufacture
21. ANSI/AWWA C-105/A21.5
22. Minimum film thickness and material type.
23. Applicable range of nominal pipe diameter size(s).
24. Warning-Corrosion Protection-Repair any Damage.

The Engineer may at no cost to the Contractor, subject random testing by an independent laboratory for compliance with this Specification. Any visible defect of failure to meet the quality standards herein will be grounds for rejecting the entire order.

Table 17	
4 MIL POLYETHYLENE WRAPPING MATERIALS	
SIZE & LENGTH (All sizes lay flat size)	
Pipe Size	Product Size Width x Length
4", 6" & 8"	20" x 200/500
8", 10" & 12"	27" x 200/500
16" & 18"	37" x 200/500
20"	41" x 200/500
24"	54" x 200/500
30"	67" x 140/500
36"	81" x 120/500
48"	95" x 100/500
54"	108" x 100/500

APPROVED MANUFACTURER AND PRODUCTS LIST

Table 18	
Manufacturer	Product
Van Leer Flexibles Inc.	Valeron
Manufactured Plastics and Distribution Inc.	Cross Tuff 450 Black

3.12

Mechanical Couplings.

Mechanical coupling of Dresser or similar type is to be used to connect plain ends of concrete steel cylinder pipe and plain ends of steel and ductile-iron pipe and to connect new and existing ductile iron water main in conjunction with casing installation in accordance with the details shown on the plans.

The mechanical coupling is to consist of a cylindrical steel middle ring, two (2) steel follower rings, two (2) rubber compound gaskets and a set of steel bolts. The middle ring is to be flared at each end to receive the wedge-shaped gasket which is compressed between the middle ring flare and the outer surface of the pipe by pressure exerted on the follower rings through the bolt circle.

The flexible and transition couplings are to be manufactured to fit the type size and class of pipe specified. Bolts are to be high strength low alloy steel meeting the requirements of AWWA Standard C-111.

3.13

Air Release Assemblies.

2.13.1.

Valve body and cover is to be cast iron fabricated in accordance with ASTM A-48-35 or ASTM A-126 Class B. Non-metallic Valve Body shall be fabricated from fiberglass reinforced nylon. Inlet sizes through 2-in. are to be screwed (National Pipe Taper Thread, NPT). Pipe sizes above 3-in. and above are to have flanged inlets (125 pounds ANSI B16.1). A protective hood or cowl is to be installed on the outlet of flange-bodied valves.

Internal seat trim float arm and pivot pin is to be stainless steel Type 303 or 304 or 316. Floats are to be stainless steel ASTM A-240. Other internal parts are to be stainless steel ASTM A-240 or ASTM A-276.

Non-metallic floats shall be foamed polyethylene with stainless steel type 316 fasteners.

Internal seat or orifice button is to be of Buna-N rubber compounded for water service. Cover gasket is to be composition-type, equal to Armstrong CS-231, Garlock 3000, or Lexide NK-511. Cover bolts are to be alloy steel. Rolling seals shall be furnished for non-metallic valves 2" and below.

Valve body is to have a test pressure rating of 300 psi and working pressure rating of 150 psi.

The air release valve is to be designed to vent accumulated air automatically. The outlet orifice is to be properly sized to facilitate valve operation at pressures up to 150 psi. The air release valve is to be either simple lever or compound lever, depending upon venting volume requirements.

The air and vacuum valve is to be designed with the inlet and outlet of equal cross-sectional area. The valve is to be capable of automatically allowing large quantities of air to be exhausted during the filling cycle and also capable of automatically allowing air to re-enter the system to prevent a negative pressure during the draining cycle. The float is to be guided to minimize premature closure by air and to provide proper alignment for normal closure by floating on the water surface.

Combination valves are to provide for both automatic air release under system pressure and to allow air movement during filling or draining operations. The combination valve may be housed in a single casting. The housing is to be designed to incorporate conventional or kinetic flow principles to properly vent the air without premature closure. Flanged sizes (4-in. and larger) may be furnished in a dual housing. When dual castings are used, a bronze manual isolation valve is to be installed. This will allow the air release valve to be serviced when the system is under pressure.

The Engineer may at no cost to the Contractor, subject random valves to testing by an independent laboratory for compliance with these standards. Any visible defect or failures to meet the quality standard herein will be grounds for rejecting the entire order.

The following qualified products list identifies specific manufactured items by catalog number that are approved.

Approved Manufacturers and Models:

2.13.2.

Air Release Valves (Inlet x Orifice)

<u>Manufacture</u>	<u>1" NPT x 3/16"</u>	<u>2" NPT x 3/16"</u>
Apco Valve Company	200A	200A
G.A. Industries, Inc. (Empire)	920	920
Multiplex Mfg. Co. (Crispin)	P1-10	PL-10A
Val-Matic Mfg. Co.	38	38
PowerSeal Corporation	5401-D	5401-E
ARI Flow Control	S-050 1T	D-040 2T

2.13.3. Air & Vacuum Valves (Inlet x Orifice)

<u>Manufacture</u>	<u>2" NPT x 3/16"</u>	<u>4" flg. with cowl</u>
Apco Valve Company	144	152
G.A. Industries, Inc. (Empire)	930	930-C
Multiplex Mfg. Co. (Crispin)	AL20	AL41
Val-Matic Mfg. Co.	102	104
PowerSeal Corporation	5402-B	5402-D
ARI Flow Control	SD-040 2T	K060 C-HF

2.13.4. Combination Air Valves (Inlet x Orifice)

<u>Manufacture</u>	<u>1"NPT</u>	<u>2"NPT</u>	<u>4"flg.</u>
	<u>X 5/64"</u>	<u>x 3/32"</u>	<u>x 3/32 w/ cowl</u>
Apco Valve Company	143C	145C	149C
G.A. Industries, Inc. (Empire)	945 (1" NPT)	945	960C
Multiplex Mfg. Co. (Crispin)	U10	UL20 (1/4")	UL41 (1/4")
Val-Matic Mfg. Co.	201C	202C	204C
PowerSeal Corporation	5403-A	5403-B	5403-D
ARI Flow Control	D-040 2T	D-040	D-060 C-HF
		D-060 C-HF	

3.14 **Blow-off Assemblies and Jumper Connections.**

The materials required for both permanent and temporary 2-in. and 4-in. blow-off assemblies and 4-in. jumper connections are shown on the plans.

3.15 **Backfill.**

- 2.15.1. Where services ¾" – 2" copper are installed, initial backfill shall be sand conforming to the following requirements: Natural sand or sand produced from crushed gravel or crushed rock maximum ¼-inch; 95 percent shall pass No. 4 sieve, free from clay and organic material, with a maximum 8 percent passing the No. 200 sieve. Larger services utilizing ductile iron pipe or PVC (C-900) pipe shall be backfilled the same as mains.

Bedding and Initial Backfill for Water Mains.

2.15.1.1. Well graded gravels or crushed stone meeting the following requirements:

Modified Grade 5 gravel:

Retained on ½" sieve	0%
Retained on 3/8" sieve	0 – 5 %
Retained on No. 4 sieve	20 - 80%
Retained on No 10 sieve	75 - 100 %
Retained on No 20 sieve	98 - 100%

The quantity and thickness of lifts and compaction of initial backfill materials is to be in accordance with subsection 3. D. 1 of this specification.

2.15.2. Secondary Backfill for Water Mains. Secondary Backfill shall consist of approved materials that are excavated from the trench and are free of brush, debris, large rock or stones and earth clods 6" or larger. Secondary backfill material shall be primarily composed of compactable soil materials.

3.16 **Asphalt.**

All asphaltic concrete used in the replacement of pavement over the trench line is to conform to Item 341, "Dense-Graded Hot-Mix Asphalt (QC/QA), Type "C", except when the use of 6-in. of asphalt treated base is directed., unless otherwise specified on the plans.

3.17 **Concrete.**

All concrete used as the trench cap and in sidewalks and blocking mains is to conform to Item 421, "Hydraulic Cement Concrete". Class "A" concrete is to be used in sidewalks and for blocking concrete steel cylinder mains; Class "D" concrete is to be used for the trench cap and for blocking all other types, unless otherwise specified on the plans.

3.18 **Reinforcing Steel.**

All bar reinforcement is to be Grades 40 or 60, conforming to the requirements of Item 440, "Reinforcing Steel".

3.19 **Affidavit of Compliance.**

Unless otherwise directed, the Contractor is to furnish a manufacturer's affidavit of compliance for each of the materials used in this project. The affidavit is to certify that factory inspection and all specified tests have been made and that the material furnished complies with the requirements outlined herein.

3. **CONSTRUCTION METHODS**

3.1 **Excavation.**

Excavation (trenching) as required to complete the water main installation is to be performed in accordance with Item 400, "Excavation and Backfill for Structures", as outlined herein, as shown on the plans and as directed

2.1.1. Trenches.

Trench walls shall be vertical. The practice of undercutting at the bottom or flaring at the top will not be permitted except where it is justified for safety or at the Engineer's and/or Inspector's direction. In special cases, where trench flaring is required, the trench walls shall remain vertical to a depth of at least 1 foot above the top of the pipe.

The trench bottom shall be square or slightly curved to the shape of the trenching machine cutters. The trench shall be accurately graded along its entire length to provide uniform bearing and support for each section of pipe installed upon the bedding material. Bell holes and depressions for joints shall be dug after the trench bottom has been graded and bedding installed. The pipe shall rest upon the new bedding material for its full length.

Where over-excavation occurs, the under-cut trench shall be restored to grade at no cost to the Department and replaced with a material conforming to the requirements of the bedding material or a material approved by the Engineer.

The depth of cut indicated on cut sheets, as furnished by the engineer, is from the off-set or cut hub elevation to the invert.

2.1.2. Width of Trench.

Minimum Width of Trench. The minimum width of pipe trenches, measured at the crown of the pipe, shall be not less than 12 inches greater than the exterior diameter of the pipe, exclusive of bells. The minimum base width of such trench shall be not less than 12 inches greater than the exterior diameter of the pipe, exclusive of special structures or connections. Such minimum width shall be exclusive of trench supports and not greater than the width at the top of the trench.

Maximum Width of Trench. The maximum allowable width of trench for pipelines measured at the top of the pipe shall be the outside diameter of the pipe (exclusive of bells or collars) plus 24 inches. A trench wider than the outside diameter plus 24 inches may be used without special bedding if the Contractor, at his expense, furnishes pipe of the required strength to carry additional trench load. Such modifications shall be submitted to the Engineer and approved in writing. Whenever such maximum allowable width of trench is exceeded, except as provided for on the drawings, or in the specifications, or by the written approval of the Engineer, the Contractor, at his expense, shall encase the pipe in concrete from trench wall to trench wall, or other pipe bedding material approved by the Engineer. Any excavation wider than this maximum width or subsequent Surface or Paving work, will be done at the Contractor's expense.

2.1.3. Classification of Excavated Materials.

No classification of excavated materials will be made. Excavation and trench work is to include the removal and subsequent handling of all materials excavated in accordance with Item 400, "Excavation and Backfill for Structures".

2.1.4. Grade of Trench Bottom.

The trench is to be over-excavated to a depth of 6-in. below the grade line established for the bottom of the pipe, regardless of the type of pipe. The grade line of the pipe is to then be met by the addition of a layer of approved bedding material as directed.

2.1.5. Excavation Below Grade.

Any part of the bottom of the trench excavated below the limits specified in Section 3.A.4., "Grade of Trench Bottom", is to be corrected with approved material and compacted as directed. Should excessive over-excavation occur, except at bell holes, the grade is to be restored in accordance with the methods described in Section 3.A.6, "Unstable Conditions at Grade", at no cost to the Department.

2.1.6. Unstable Conditions at Grade.

Where the bottom of the trench at grade is found to be unstable or to include ashes, cinders, any type of refuse, vegetable or other organic material, or large pieces of fragments or inorganic materials which in the judgment of the Engineer should be removed, the Contractor is to excavate and remove such unsuitable material to the a depth no less than 6-inches below pipe. Before the pipe is laid the grade is to be restored by backfilling with an approved material in layers of 3-in. prior to compaction. The layers are to be slightly moistened and thoroughly compacted so as to provide a uniform and continuous bearing and support for the pipe at every point between bell or collar holes. The finished grade is to be accurately graded to provide uniform bearing and support for each section of pipe at every point along its entire length except for the portions of the pipe sections where it is necessary to excavate for bell holes and for the proper seating of pipe joints.

2.1.7. Trench Excavation Protection.

All trench excavation required on this project is to be accomplished as required by the provisions of Item 402, "Trench Excavation Protection".

2.1.8. Caution in Excavation.

The Contractor is to proceed with caution in the excavation and preparation of the trench so that the exact location of underground structures and utilities may be determined whether shown on the plans or not. Machine excavation is not permitted closer than 12-in. on either side of other existing underground utilities. The Contractor is to be responsible for the repair of such structures and utilities when broken or damaged. He is also to be responsible for adjusting alignment and trench grades with reference to such structures in order to obtain specified clearance for the water main construction.

Whenever the Engineer determines that it is necessary to explore and excavate to determine the location of existing underground structures and utilities, the Contractor is to make explorations and excavations for such purposes at his expense.

2.1.9. Protection and Restoration of Underground Structures and Facilities.

The Contractor is to furnish temporary support, adequate protection, and maintenance of all underground and surface structures, drains, sewers, and other obstructions encountered in the progress of the work. All underground structures and utilities which are disturbed are to be restored by the Contractor at his expense. Materials and methods used for restoration are to be in accordance with the Local City Codes, of the local municipality, for Building, Electrical, and Plumbing and the requirements of the utility agency involved.

In the event that a sanitary sewer is broken by the Contractor's operations the release of sewage into the trench is to be immediately intercepted by the insertion of a section of sheet metal tubing known as a "tin-horn" between the broken ends of the sewer. All leakage at the ends of the "tin-horn" is to be effectively stopped. The "tin-horn" is to remain in place until such time as permanent repairs can be made. It is to be the responsibility of the Contractor to determine sufficiently in advance of his trenching operations the size of all sanitary sewer lines and services which will require this treatment.

All sanitary sewer lines crossing the excavation, whether bridged or replaced, are to have proper support consisting of sound timber supports having a minimum 2-in. nominal thickness and a minimum 6-in. nominal width placed with the width horizontal and extending a minimum of 12-in. into the trench wall on either side.

In all cases where a sewer pipe is replaced or bridged, the backfill material is to be thoroughly compacted to the bottom of the pipe and compacted by hand from this point to a distance of 6-in. above the top of the sewer line being replaced.

The locations of all sewer lines crossing excavations, whether replaced or bridged are to be properly marked, and care is to be taken to avoid damage to the pipe through the use of a hydratamping machine or other mechanical equipment. The Contractor is to be liable for the failure of such lines due to negligence or poor workmanship.

2.1.10. Backfill Material Derived from Excavation.

2.1.10.1. All excavated materials which the Engineer determines are suitable for reuse as trench backfill is to be separated where practicable from the general excavation material, or as directed.

2.1.11. Trench Restoration

The surface of the backfilled trench shall be restored to match the previous existing conditions. This shall include final grading, placement of topsoil and seeding, placement of sod (such as at homes or businesses that had maintained lawns), or other unprepared and prepared surfaces. Trenches in alleys actively being used by vehicles (such as trash pickup, vehicle parking, etc.) shall be restored by grading and compacting to 98% or higher with a minimum of 4 inches of flex-base materials for the entire width of the alley. Alleys not actively used by vehicles shall be graded and compacted to 98% or higher, then spread grass seed for entire width of the alley.

2.1.12. Pavement.

The Contractor is to remove pavement and surfaces as a part of the trench excavation. The removal of pavement and surfaces and their restoration is to be based on the minimum trench widths as specified, plus 6-in. either side or as otherwise provided herein. The Contractor is to use such methods as sawing, drilling, or chipping to assure the breaking of the pavement along straight lines.

If the Contractor removes or damages pavement or surfaces beyond the limits specified above, such pavement and surfaces are to be restored at the expense of the Contractor.

Where water line construction necessitates cutting through existing streets outside the limits of new street construction, said streets are to be replaced in kind as directed.

Where, in the opinion of the Engineer, it is necessary to maintain traffic across a trench, the Contractor is to install temporary metal bridges as necessary to facilitate the movement of traffic.

The street surface adjacent to the trench is to be kept free of surplus spoil. Construction materials are to be placed at locations that will minimize interference with the traveling public.

2.1.13. Fence.

Removing and replacing chain-link and/or wire fence as required. The existing fence materials may be reused unless, the existing materials were damaged during removal and should not be reused. The Contractor is to provide new material for the replacement work at his expense.

2.1.14. Concrete Sidewalks, Driveways, Etc.

All concrete sidewalks, driveways, etc., are to be cut with a concrete saw. When transverse expansion or "dummy" joints are encountered, the concrete is to be removed to the nearest transverse joint on each side of the trench and restored. The depth of cut is to be such that upon removal of the concrete, the sides of the cut are to be straight and square.

Existing reinforcing wire fabric or bars are to be cut and removed to permit completion of trench excavation, pipe laying, and backfill operations. When the backfill operations have been completed, the existing reinforcement is to be replaced in its original position and satisfactorily spliced prior to the replacement of concrete over the new trench alignment.

Transverse "dummy" joints are to be made by a jointing tool or other means acceptable, and are to match in depth and thickness in the existing transverse joints.

Expansion joint material is to be provided where new construction abuts the existing curb or driveway if the Engineer deems it necessary.

Concrete is to be spaded, tamped, and thoroughly compacted until mortar entirely covers the surface and has a monolithic finish. The top surface is to be floated, troweled, and finished to match the existing concrete surface.

Immediately after finishing, the concrete surface is to be protected by a membrane compound curing agent, or by wetted cotton or burlap mats. Either method is to be subject to approval.

2.1.15. Dewatering.

Prevent surface water and subsurface or ground water from flowing into excavations and from flooding project site and surrounding areas.

2.1.15.1. The contractor shall not allow water to accumulate in excavations or at subgrade level. Remove water to prevent softening of foundation bottoms and soil changes detrimental to stability of subgrades and foundations. Provide and maintain dewatering system components necessary to convey water from excavations.

2.1.15.2. Convey water removed from excavation and rainwater to collecting or runoff areas away from buildings and other structures. Establish and maintain temporary drainage ditches and other diversion outside excavation limits. Do not use trench excavations as temporary drainage ditches.

2.1.15.3. Dewatering devices shall be provided by the Contractor with filters to prevent the removal of fines from the soil.

Should the pumping system draw fines from the soil, the Engineer shall order immediate shutdown, and remedial measures will be the responsibility of the Contractor.

2.1.15.4. Upon completion of the dewatering work, the Contractor shall remove all equipment and leave the construction area in a neat, clean, condition that is acceptable to the Engineer.

2.1.15.5. The Contractor shall maintain ground water table at least 12 inches below the finished excavation subgrade.

2.1.15.6. Dewatering Performances. Performances of the dewatering system for lowering ground water shall be measured by observation wells on piezometers installed in conjunction with the dewatering system, and these shall be documented at least daily. The Contractor shall maintain a log of these readings and submit them to the Engineer.

No direct payment shall be made for costs associated with dewatering. All costs in connection therewith shall be included in the applicable contract price for the item to which the work pertains.

3.2 **Pipe Laying.**

2.2.1. General Requirements.

All water mains shall be constructed in accordance with the specifications herein outlined and in conformity with the required lines, grades, and details shown on the plans and as directed by the Engineer. Successful passage of the pressure testing and disinfection, as described under TCEQ 30 TAC 290.44 Criteria, shall be required for the acceptance of the mains.

Water Main Crossings: Where water mains are constructed in the vicinity of sanitary sewer mains, sanitary sewer force mains, sanitary sewer manholes and other sanitary sewer facilities, including non-potable waters such as wastewater effluent used in "reuse" applications, the requirements of the TCEQ 30 TAC 290.44 (e) & (f) shall be met.

The Contractor is to start his work at a tie-in point, unless otherwise indicated on the plans. Pipe is to be laid with bell ends facing the direction of lying, unless otherwise authorized or directed. Under no circumstances is pipe to be laid in water and no pipe is to be laid under unsuitable weather or trench conditions. All valves and fire hydrants must be installed as soon as pipe laying reaches their established location. Pipe is to be installed to the required lines and grades with fittings, valves, and hydrants placed at the required locations.

Spigots are to be centered in bells or collars, all valves and hydrant stems are to be set plumb, and fire hydrant nozzles are to face as shown on the plans or as directed. No valve or other control on the existing system is to be operated for any purpose by the Contractor unless approved.

The Contractor is to maintain a neat and orderly work area. Complete cleanup is to be maintained at all times as closely behind the pipe laying operations as possible, but in no case is such cleanup be permitted to lag more than 1,000-ft. behind the pipe laying, unless otherwise directed.

2.2.2. Crossing other Underground Lines.

New water mains crossing other utilities (not including sanitary sewer or "reuse" facilities) are to have a minimum of 30-in. of cover over the top of the pipe unless otherwise waived or modified. Excavation around other utilities is to be done by hand for at least 12-in. all around. Any damage to the protective wrap on gas lines or electrodes is to be reported immediately to owner of the gas utility, contact information as shown in the plans. Any damage to other utilities shall be immediately reported to the utility owner.

2.2.3. Pipe Grade.

Water mains 16" or smaller shall have a minimum of 48 inches of cover from the proposed final finish ground/street elevation and 60 inches of cover when the main is installed in a parkway or under the pavement where there are no existing/proposed curb or existing drainage facilities. Water mains 20" and above shall have a minimum of 60 inches of cover over the top of the pipe from the proposed final finish ground/street elevation unless otherwise waived or modified by the Engineer.

Pipe grades are to be as required on the plans, or as directed. Grades are to be met as specified by Section 3.A, "Excavation". Care is to be taken to insure that the pipe barrel has uniform contact with the bedding material for its full length except at couplings. The coupling is not to be in contact with the original trench bottom prior to backfill. Bedding material is to be placed under the coupling and compacted by hand prior to backfilling so as to provide an even bearing surface under the coupling and pipe. Change in grade is to be made only at joints.

2.2.4. Bedding and Bedding Materials.

Prior to placing pipe in a trench, the trench is to have been excavated to the proper depth as required in Section 3.A, "Excavation". Approved materials are to be smoothly worked by hand across the entire width of the trench bottom to provide supporting bedding for the pipe.

Structures to Support Pipe: Where as the bottom of a trench at subgrade consist of material that is notably unstable by the Engineer and cannot be removed and replaced with approved material may be properly compacted in place to support the pipe. The Contractor shall also construct a foundation for the pipe consisting of piling, concrete beams, or other supports in accordance with plans prepared by the Engineer. Extra compensation will be allowed for the Contractor for the additional work done. Coordinate with Engineer for approval of extra compensation prior to beginning work.

2.2.5. Lowering Materials into Trench.

Proper implements, tools and facilities satisfactory to the Engineer are to be approved and used by the Contractor for the safe and convenient execution of work. All pipe, fittings, valves, and hydrants are to be carefully lowered into the trench piece by piece by means of a derrick, ropes, or other suitable tools or equipment in such a manner as to prevent damage to water main materials and protective coatings and lining. Under no circumstances are water main materials to be dropped or dumped into the trench. Take

care to avoid damaging polywrap films. Use of chains or slings is not allowed unless entire sling is wrapped with a protective nylon web sock.

2.2.6. Installing Pipe.

Every precaution is to be taken to prevent foreign material from entering the pipe while it is being placed in the line. Under adverse trench conditions, extended period of time and/or otherwise required by the Engineer, a manufactured cap/plug is to be used to prevent any foreign type material entering. Leave the cap/plug in place until a connection is made to the adjacent pipe. Inspect the interior of each pipe for defects and reject if defects are found.

After placing a length of pipe in the trench, the jointed end is to be centered on the pipe already in place, forced into place, brought to correct line and grade, completed in accordance with the requirements specified herein. The pipe is to be secured in place with approved backfill material tamped around it. Pipe and fittings which do not allow a sufficient and uniform space for joints will be rejected and are to be replaced with pipe and fittings of proper dimensions. Precautions are to be taken to prevent dirt or other foreign matter from entering the joint space.

At times when pipe laying is not in progress the open end of pipe in the trench is to be closed by a watertight plug or other means approved. Pipe in the trench which cannot temporarily be jointed is to be capped or plugged at each end to make it watertight. This provision is to apply during all periods when pipe laying is not in progress.

Should water enter the trench, the seal is to remain in place until the trench is completely dry. The Contractor is to provide plug & caps of various sizes required.

- 2.2.6.1. Steel Pipe: Steel pipe shall be installed as specified within "Water Main." The Contractor shall furnish all steel piping including fittings, couplings, specials, pipe supports, eyebolts, nuts, and accessories which are shown on the plans and as required for proper connection to existing piping. The Contractor's attention is directed to the fact that the exact location and elevation of existing piping must be determined in the field prior to fabrication of connecting piping.

All steel pipe and specials may be either mill pipe or fabricated pipe and, in either case, shall be fabricated to the sizes, dimensions and shapes as indicated on the plans and as shown on the plans. Unless otherwise indicated on the plans, all steel pipe, bends, or specials shall have an outside diameter minimum wall thickness and unit weights as shown on plans.

- 2.2.6.1.1. Ends of Sections: Ends of pipe sections, bends, and specials shall be beveled for field welding, unless shown otherwise on the plans.

- 2.2.6.1.2. Seams: All piping shall be made from steel plate rolled into cylinders or sections thereof, with not more than two longitudinal butt welds, or shall be spirally formed and butt welded. Girth seams shall be butt welded and not be closer than 6 feet apart except in specials and bends.

- 2.2.6.1.3. Length tolerance: Standard and special section shall be within 1/16 inch (plus or minus) of the specified or theoretical lengths.

- 2.2.6.1.4. Welded Joints: Except where ends are shown on the plans to be joined by mechanical couplings, all joints for steel pipe installed on a bridge structure and in open trench shall be welded.

Welders appointed to do welding on steel pipe shall be certified with 4F and 5G certification. All welds shall be sound, free from embedded scale and slag, shall have a tensile strength across the weld not less than that of the thinner of the connective sections, and be water tight. Use butt welds for all welded joints in line-pipe assemblies and in the fabrication of bends and other specials. Welds are subject to Pre-Manufacturing inspection and available to the Engineer by request.

Welding for field joints shall conform to the applicable requirements of the AWWA "Standard Specification for Field Welding of Steel Water Pipe Joints, C-206." Parties involved in the construction of main(s) shall pay special attention to the AWWA "Standard Specification for Field Welding of Steel Water Pipe Joints, C-206, Control of Temperature Stresses." After welding, the joints shall be prepared, primed and painted, or wrapped in accordance with this specification.

Repair leaks in welds by chipping out defective material and re-welding. Hammering is not permitted.

- 2.2.6.2. PVC (C-900 and C-905): Lay PVC mains to the depths and grades shown on plans. Lay pipe by inserting spigot end into bell flush with insertion line or as recommended by manufacturer. At no time is bell end allowed to go past "insertion line". A gap between end of spigot and adjoining pipe is necessary to allow for expansion and contraction.

All mains consisting of PVC (C-905) joint restraints shall be installed as specified in accordance with manufacturer's recommendations. Joint restraints shall be non-directional and installed as shown on the Joint Restraint Standard Detail Drawing or as shown on the plan drawings. The Contractor may be required to restrain additional joints depending on the size of main and at the direction of the Inspector or Engineer.

PVC (C-905) shall be field cut using a power saw with a steel blade or abrasive disc depending on the size of pipe. If a bevel is needed after field cutting, it should be in accordance with Uni-Bell recommendations.

Tracer Wire: Tracer wire shall be utilized for location purposes and tapped to the pipe. Tracer wire shall be of solid core (14 gauge insulated), and shall be taped to the main in minimum 10 inch increments. The tracer wire shall also come up to the top of valve extensions and fire hydrant stems, as directed by the Inspector.

- 2.2.6.3. Ductile Iron Pipe: Excavations at Bells and Collars: Ductile Iron pipe shall be installed as specified within these specifications. Bell holes of sufficient size shall be provided at each joint to permit the joints to be made properly. For mechanical type joints, the minimum clearance between the bell and natural ground shall be 6 inches in all directions. Subject to the above provisions, the length of excavation for bell holes below grade of the trench bottom shall be kept to a minimum.

Except as otherwise shown on the plans or as directed by the Engineer, anti-corrosion embedment shall be provided for all ductile iron pipe, fittings, and valves and at all valves, fittings, or outlets for nonferrous or reinforced concrete steel cylinder pipe. The embedding material shall conform to the requirements as set forth in Section 2.O.1.a Backfill.

The preparation of the trench shall be as set forth elsewhere in these specifications. After the subgrade has been prepared, the pipe shall be laid to grade in accordance with these specifications. The pipe, fitting, or valve shall be firmly embedded in and surrounded by an insulating blanket of the embedding material. The minimum thickness of this blanket shall be 6 inches in every direction.

Where ductile-iron pipe is to be installed in a bore, the pipe shall be thoroughly cleaned down to the coal-tar enamel pipe coating by approved methods. Where damaged, a prime coat compatible to the polyvinyl tape to be used shall then be applied to the pipe. Following the application of the prime coat, the pipe shall be wrapped with Scotchrap, Trantex V-10 polyvinyl tape, or an approved equal. The tape shall not be applied until the prime coat is completely dry.

The tape shall be spirally and tightly wrapped on each section of the pipe with a 50% lap. The wrap shall be made to the bell on the bell end and to a point 6 inches from the spigot end. The joint shall be protected with tape 6 inches in width on pipe 12" or less in size and with tape 8 inches in width on pipe greater than 12" in size.

Ductile-iron pipe to be installed in a trench shall be protected in the following manner. Each pipe joint shall be covered with a 4 mil thick polyethylene sleeve that is 2 feet longer than the pipe joint. The sleeve shall cover the full length of the pipe joint, lap over 1 foot on each end of the adjoining pipe joints, and be secured with a minimum of two circumferential turns of pressure sensitive polyvinyl tape. Excess material should be neatly drawn up around the pipe barrel, folded into an overlap on top of the pipe, and held in place by means

of pieces of pressure sensitive tape at approximately 5 foot intervals. After assembling the joint, the polywrap tube from the previously installed pipe shall be pulled over the joint and secured by the Contractor. The polywrap tube from the new joint shall be pulled over the first tube and secured by the Contractor to provide a double seal.

Cast-iron and Ductile-iron fittings and valves shall be completely wrapped in 8 mil thick polyethylene film with a minimum of one 1 foot overlap on each end and appropriately taped. Laps shall cover joints with adjoining pipe joints or fittings when installed. Fire Hydrant barrel from the surface to the valve shall be wrapped as specified herein.

Any damaged areas in the polyethylene film shall be repaired by covering the area with a sheet of polyethylene film large enough to lap over the damaged area 1 foot minimum in any direction and appropriately taped. Extreme care shall be taken at service tap locations to insure that the tape extends beyond the corporation and onto the service line pipe 1 foot.

Prior to placing pipe in the trench, a cushion of approved materials shall be placed in the trench as required by in the trenching specifications contained herein. Backfill material shall be carefully placed on the pipe so as to avoid any damage to the polyethylene sleeve.

The Contractor shall use care to protect and reserve the polyethylene wrap around ductile iron water mains when installing service corporations. The required method is to wrap pipe tape around the pipe over the polywrap in the area to be tapped. The tap is to be made through the tape and polywrap. It is not necessary to remove and replace poly wrap. All exposed pipe, the corporation, and the first 3 feet of the service shall be wrapped and taped to achieve a complete seal. In addition, a sand envelope shall extend over and around the connection to a depth of eight inches above the main.

All bolts and nuts destined for underground service on valves, fire hydrants, cast-iron mechanical joint fittings, pipe joints, and other ferrous metal appurtenances shall be packed in an approved protective coating material after installation. After the joint has been made and bolts drawn to the proper tension, the joint including glands, flanges, bolt heads, and nuts shall be covered with an Engineer approved protective coating. Such protective coating shall be supplemental to anti-corrosive sand embedment as set forth elsewhere in these specifications. Coating and wrapping of joints will be considered incidental to the installation, and no separate payment will be made for this item. Asphaltic material such as Talcote, and other asphaltic type coatings, shall not be used.

All cuts made on ductile-iron pipe shall be done with a power saw or approved mechanical cutter. The cuts shall be made at right angles to the pipe axis and shall be smooth. The edges of the cut shall be finished smoothly with a hand or machine tool to remove all rough edges. The outside edge of pipe should be finished with a small taper at an angle of about 30 degrees.

2.2.7. Defective or Damaged Material.

Pipe and accessories are to be inspected for defects prior to being lowered into the trench. Any pipe section, fitting, or special which shows dents, kinks, abrupt changes of curvature other than specified, or any other damage will be rejected. Any pipe section, fittings, or special section that has been dropped (from a truck or crane, etc.) will be rejected. The Contractor shall, at his expense, replace or recondition each rejected section. Reconditioning procedures must be acceptable to the Engineer. Any defective, damaged, or unsound material is to be repaired or replaced as directed.

Should a damaged piece of pipe furnished by the Contractor be placed in the water main, the Contractor is to furnish, at his expense, all labor and materials required for removing and replacing the defective pipe and restoring the street to its condition just prior to the failure of the pipe. Should the Contractor damage the pipe after installation, the Engineer may permit the damaged section to be cut from the length unless it is the opinion of the Engineer that the entire length was damaged. The cost and replacement of broken pipe is to be at the expense of the Contractor.

2.2.8. Holes at Bells and Collars.

Bell holes of sufficient size are to be provided at each joint to permit the joints to be made properly. For mechanical type joints the minimum clearance between the bell and natural ground is to be 6-in. in all directions. Bell holes for concrete steel cylinder pipe are to be of sufficient size to properly joint the pipe and place the required grout. Subject to the above provisions the length of excavation for bell holes below grade of the trench bottom is to be kept to a minimum.

2.2.9. Deviations in Line or Grade.

Wherever obstructions, not shown on the plans, are encountered during the progress of the work and such obstructions interfere to such an extent that an alteration on the plan is required, the Engineer is to have the authority to change the plans and direct a deviation from the line and grade or to arrange with the owners of the structures for the removal, relocation, or reconstruction of the obstruction. Any deviation from the line is to be accomplished by the use of appropriate bends unless such requirements are specifically waived by the Inspector.

Whenever it is necessary to deflect pipe from a straight line the deflection is to be as directed. In no case are the amounts shown in Table 19, "Maximum Deflections of Ductile-Iron Pipe", for ductile-iron pipe, and Table 20, "Maximum Deflections of Concrete-Steel Cylinder Pipe", for concrete pipe to be exceeded.

Table 19
Maximum Deflections of Ductile-Iron Pipe

Norm Pipe Dia	Max Joint Open	Max Defl Angle	Max Deflection in Inches with Pipe Length of:		Approx Rad of Curve in Ft Produced by Succession of Joints with Pipe Lgth of:	
(Inch)	(Inch)	Deg/Min	18ft	20ft	18ft	20ft
6	0.58	4/25	16.7	18.5	234	260
8	0.65	3/51	14.6	16.2	268	297
10	0.75	3/42	14.0	15.5	279	310
12	0.75	3/08	11.9	13.2	327	363
16	0.75	2/21	8.8	9.7	440	488
20	0.75	1/55	7.2	8.0	540	600
24	0.75	1/35	6.0	6.7	648	720

Table 20
Maximum Deflections of Concrete-Steel Cylinder Pipe

Normal Pipe Diameter (Inches)	Maximum Deflection Angle Deg/Min	Maximum Deflection (Inches)		Approx Radius of Curve (Feet)	
		16' Lay Length	20' Lay Length	16' Lay Length	20' Lay Length
16	2/20	-	9.8	-	500
20	1/52	-	7.8	-	600
24	1/34	-	6.6	-	750
30	1/16	-	5.3	-	900
36	1/02	-	4.3	-	1100
42	0/54	-	3.8	-	1300
48	0/47	2.6	-	1170	-
54	0/44	2.5	-	1237	-
60	0/54	3.0	-	1024	-

2.2.10. Cutting Pipe.

The cutting of pipe for inserting valves, fittings or closure pieces is to be accomplished so as to produce a smooth end at right angles to the axis of the pipe. Strictly follow the recommendations of the pipe manufacturer. Under no circumstances is a workman not equipped with proper safety goggles and helmet and other required safety attire permitted to engage in this work.

Asbestos-Cement (AC): No field cutting will be allowed on asbestos-cement pipe. Repairs to AC pipe shall be accomplished by removing one full joint of AC pipe and replacing with appropriate PVC or Ductile Iron pipe and fittings.

All cuts made on ductile-iron pipe are to be done with a torch or power saw. The cuts are to be made at right angles to the pipe axis and are to be smooth. The edges of the cut are to be finished smoothly with a hand or machine tool to remove all rough edges. The outside edge of pipe should be finished with a small taper at an angle of about 30°.

Field Cut PVC (C-900 and C-905) using a power saw with a steel blade or abrasive disc depending on the size of pipe. If a bevel is needed after field cutting, it should be in accordance with Uni-Bell recommendations.

To facilitate future repair work on water mains, no sections less than 3 feet in length between fittings is allowed.

2.2.11. Coating and Wrapping Underground Pipe.

2.2.11.1. Steel Pipe.

Steel pipe, bends and special are to be prepared, primed, painted or wrapped in the field as follows.

2.2.11.1.1. Exterior Surface Above Ground: Exterior surfaces of new pipe and appurtenances installed are to be thoroughly cleaned to bare metal by high speed wire brushing, scraping or other suitable methods approved

by Engineer, given a single coat of industrial grade rust inhibitive primer and two finish coats of aluminum paint.

2.2.11.1.2. Exterior Surfaces Underground: Exterior surface of steel pipe, bends and specials installed in open trench are to be thoroughly cleaned to bare metal by high speed wire brushing, scraping or other suitable methods approved by Engineer, given a single coat rust inhibitive primer and wrapped with polyvinyl tape in accordance with AWWA C-203-91 "Protective Coatings for Steel Water Pipelines," (Appendix C).

2.2.11.1.3. The procedure for coating flanged joints and mechanical coupling joints when used with steel pipe is to be as specified."

2.2.11.1.4. Interior Surfaces: The interior surfaces of steel pipe, fittings and specials are to be cleaned by sandblasting and then primed and coated in the shop with coal tar enamel.

2.2.11.2. Ductile-Iron Pipe.

2.2.11.2.1. Open Trench: Ductile-iron pipe to be installed in a trench is to be protected in the following manner. Each pipe joint is to be covered with a 4 mil thick polyethylene sleeve that is 2-ft. longer than the pipe joint. The sleeve is to cover the full length of the pipe joint, lap over 1-ft. on each end of the adjoining pipe joints and be secured with a minimum of 2 circumferential turns of pressure sensitive polyvinyl tape. Excess material should be neatly drawn up around the pipe barrel, folded into an overlap on top of the pipe and held in place by means of pieces of pressure sensitive tape at approximately 5-ft. intervals. After assembling the joint, the polywrap tube from the previously installed pipe is to be pulled over the joint and secured by the contractor. The polywrap tube from the new joint is to be pulled over the first tube and secured to provide a double seal.

Cast iron and ductile-iron fittings are to be completely wrapped in 8 mil thick polyethylene films with a minimum of 1-ft. overlap on each end and appropriately taped. Laps are to cover joints with adjoining pipe joints or fittings when installed. Fire hydrant barrel from the surface to the valve is to be wrapped as specified herein.

Any damaged areas in the polyethylene film are to be repaired by covering the area with a sheet of polyethylene film large enough to lap over the damaged area 1-ft. minimum in any direction and appropriately taped. Take care at service to locations to insure that tape extends beyond corporation and onto service line pipe 1 foot.

Prior to placing pipe in the trench, a cushion of approved materials is to be placed in the trench as required by Section 3.D., Backfill material is to be carefully placed on the pipe so as to avoid any damage to the polyethylene sleeve.

Use care to protect and preserve polyethylene wrap around ductile iron water mains when installing service corporations. The required method is to wrap pipe tape around pipe over polywrap in the area to be tapped. The tap is to be made through the tape and polywrap. It is not necessary to remove and replace polywrap. All exposed pipe, the corporation and the first 3 feet of the service shall be wrapped and taped to achieve a complete seal. In addition, a sand envelop shall extend over and around the connection to a depth of eight inches above the main.

2.2.11.2.2. In Casing: Where ductile-iron pipe is installed in a bore, the pipe is to be thoroughly clean down to the coal-tar enamel pipe coating by approved methods. Where damaged, a prime coat compatible to the polyvinyl tape to be used is to then be applied to the pipe. Following application of prime coat, wrap pipe with Scotchrap, trantex V-10 polyvinyl tape, or approved equal. Tape shall not be applied until prime coat is completely dry.

Tape is to be spirally and tightly wrapped on each section of pipe with 50% lap. Wrap shall be made to bell on bell end and to a point 6 inches from spigot end. Protect joint with tape 6 inches in width on pipe 12 inches or less in size and 8 inches on width on pipe greater than 12 inches in size.

2.2.12. Protective Coating and Wrapping on Joints.

All bolts and nuts installed for underground service on valves, fire hydrants, cast-iron mechanical joint fittings, pipe joints, and other ferrous metal appurtenances are to be packed in an approved protective coating material after installation. After the joint has been made and bolts drawn to proper tension, the joint including glands, flanges, bolt heads, and nuts are to be covered with an approved coating. Such protective coating is supplemental to anti-corrosive sand embedment. Asphaltic coatings such as Talcote, or other asphaltic type coatings, are not allowed. Coating and wrapping of joints is to be considered subsidiary to the installation and will not be paid for directly.

- 2.2.12.1. Steel Pipe Field Welded Joints: After installation of pipe, bends and specials, all end of pipe adjacent to welded field joints, including the weld proper, shall be cleaned, primed, painted or wrapped as specified for the pipe adjacent to the weld.
- 2.2.13. Joint Assembly.
- 2.2.13.1. Rubber Ring Joints: The installation of pipe and the assembly of rubber ring joints for ductile-iron pipe, concrete-steel cylinder pipe and asbestos cement pipe, is to conform to the pipe manufacturer's assembly instructions. The method of inserting spigot ends of pipe in bells or collars known as "stabbing" is not permitted with pipe larger than 6-in.in size. Spigot ends of pipe larger than 6-in. in size must be properly inserted in the joint by means of suitable pushing or pulling devices.
- 2.2.13.2. Mechanical Couplings: The installation of mechanical couplings is to be assembled and installed according to the standards recommended by the manufacturer. Prior to the installation of the mechanical coupling, the pipe ends are to be cleaned by wire brush or other acceptable method to provide a smooth bearing surface for the rubber compression gasket. The pipe is to be marked to align the end of the coupling which will center it over the joint. After positioning, the nuts are to be drawn up finger tight. Uniform pressure on the gaskets is to be applied by tightening alternate bolts on the opposite side of the circle in incremental amounts. Final tensioning is to be accomplished with a torque wrench and in a manner similar to the tightening procedure. The coupling is to then be left undisturbed for 24 hours to allow the gaskets to "pack-in". Final torque check is to then be made prior to coating and wrapping the joint. Table 21, Torque for Mechanical Couplings, sets forth the proper torque for various sized mechanical couplings and is included for the convenience of the Contractor.
- 2.2.13.3. Restrained Joints: Install restraint joints as shown on plans or as directed by the Engineer. Install in accordance with manufacturer's recommendations.

Table 21		
Torque for Mechanical Couplings		
Coupling Size	Bolt Diameter	Torque
2" to 24"	5/8"	75 ft/lb
2" to 24"	3/4"	90 ft/lb
30" and 36" (1/4"x7" Middle Rings)	5/8"	65 ft/lb
30" thru 36" (3/8" & heavier Middle Rings)	5/8"	70 ft/lb
30" to 48"	3/4"	80 ft/lb
48" to 72"	3/4"	70 ft/lb

2.2.14. Gray Iron and Ductile Iron Fittings.

2.2.14.1. Fittings: Fittings 6-in. through 12-in. in size are to be either mechanical joint, push-on joint short body, or push-on joint compact body unless otherwise stated on the plans. Fittings shall be installed with the thrust blocking or joint restraint shown in standard drawing DD-839 series. Fittings 16-in. through 24-in. in size are to be mechanical joint type unless otherwise specified on the plans. Adaptors are to be used where necessary to provide a transition between asbestos-cement pipe and the fittings. Restraint or thrust blocking is to be provided as specified on the plans or as directed. Anti-corrosion embedment incidental to all installed cast-iron fittings shall be provided as specified in and no separate payment will be made for this embedment.

2.2.14.2. Cleaning Ductile Iron: All lumps, blisters, and excess coal-tar coating is to be removed from the ends of ductile-iron pipe fittings. The outside of the spigot and the inside of the bell is to be wire-brushed and wiped clean, dry, and free from oil and grease before the pipe is laid. The interior of the pipe is to be blown clean with compressed air or swabbed out clean and dry as directed. Immediately prior to placing any pipe in the trench the interior is to be cleaned by an approved brush or swab or with compressed air to remove all dirt and foreign materials. All pipe and fittings are to be inspected by the Contractor for defects while suspended above ground.

2.2.15. Corrosion Protection for Ferrous Pipe, Fittings, and Valves

Except as otherwise shown on plans or as direct, anticorrosion embedment is to be provided for all ductile-iron pipe, fittings, and valves and at all valve fittings or outlets for nonferrous or reinforced concrete steel cylinder pipe. The embedding material is to be Modified Grade 5 gravel washed sand which conforms to the requirements set forth in Section 2.O.

Prepare the trench in accordance with applicable provisions of Section 3.A. After subgrade has been prepared, lay pipe to grade in accordance with the plans and specifications. Pipe, fitting or valve are to be firmly embedded in and surrounded by an insulating blanket of embedding material. The minimum thickness of this blanket is to be 6 inches in every direction

2.2.16. Tie-in to Existing Mains.

The Contractor is to make all ties to existing mains shown on plans or as directed. Contractor is responsible for; shutdowns and isolation of existing main, coordinating with the Water System Utility Owner on site prior to cutting pipe for connection, dewatering the excavation, customer notification of shutdown, proper material and all other requirements as directed by the Engineer to provide completion in a safe and secure manner. Tie-ins are to be done during normal work hours, (8 am – 5 pm). During construction, planned shutdown and tie-in shall be coordinated through and approved by the Engineer. Planned shutdown and tie-in is to be accomplished at a time which will be at the least inconvenience to customers. No additional compensation will be provided for tie-ins accomplished after normal working hours. Tie-in to existing mains of asbestos cement (AC) pipe, the Contractor shall observe and comply with all federal, state and local laws, ordinances and regulations regarding the management of asbestos containing materials. At the minimum, work involving AC pipe should be overseen by a person who has received asbestos training and is familiar with the National Emissions Standards for Hazardous Air Pollutants (NESHAP). If greater than 260 linear feet of pipe is to be removed, written notification to the Texas Department of Health (TDH) 10 days prior commencing with the removal of AC pipe is required. At each location shown in the plans and/or identified by the Contractor to involve AC pipe, the Contractor will be required to coordinate with the Department's Evergreen Contractor for the removal of the necessary amount of AC pipe required to make the connection without creating any friable material. The Department's Evergreen Contractor will remove whole sections of AC pipe so that the Contractor can make the tie-in at the nearest joint. The Department's Evergreen Contractor will remove the AC pipe, store it in a secure Engineer approved location, and then dispose of it. Prior to requiring the services of the Department's Evergreen Contractor, the Contractor shall notify the Engineer and the Owner of the Utility of the work schedule a minimum of two weeks in advance of requiring such services in order not to delay the overall project. Delays or claims made by the Contractor, resulting from the failure to provide advanced notification and schedule coordination with the Department's Evergreen Contractor, will not be a basis for additional compensation.

2.2.17. Abandonment of Old Mains and Valves.

The Contractor is to accomplish all cutting, capping, plugging, and blocking necessary to isolate those existing mains retained in service from those abandoned. The open ends of abandoned mains and all other openings or holes in such mains occasioned by cutting or removal of outlets are to be blocked off by manually forcing cement grout or concrete into and around the openings in sufficient quantity to provide a permanent substantially watertight seal.

Valves abandoned in the execution of the work are to have the valve box and extension packed with sand to within 8-in. of the finished surface. The remaining 8-in. are to be filled with 2,500 psi concrete or an equivalent sand-cement mix and finished flush with the adjacent pavement or ground surface. The valve covers are to be salvaged and returned to the Water System Company. Abandoning old mains and valves is to be considered subsidiary to the installation and will not be paid for directly.

2.2.18. Jacking, Boring, or Tunneling Pipe.

2.2.18.1. Jacking: Suitable pits or trenches shall be excavated for the purpose of jacking operations for placing end joints of the pipe. When trenches are cut in the side of embankment, such work shall be securely sheeted and braced. Jacking operations shall in no way interfere with the operation of railroads, streets, highways or other facilities and shall not weaken or damage such facilities. Barricades and lights shall be furnished as directed by the Engineer to safeguard traffic and pedestrians.

The pipe to be jacked shall be set on guides to support the section of pipe being jacked and to direct it in the proper line and grade. Embankment material shall be excavated just ahead of the pipe and material removed through the pipe, and the pipe forced through the opening thus provided. The excavation for the underside of the pipe, for at least $\frac{1}{3}$ of the circumference of the pipe, shall conform to the contour and grade of the pipe. A clearance of not more than 2 inches may be provided for the upper half of the pipe.

The distance that the excavation shall extend beyond the end of the pipe shall depend on the character of the material, but it shall not exceed 2 feet in any case.

The pipe shall be jacked from downstream end. Permissible lateral or vertical variation in the final position of the pipe from line and grade will be as shown on the plans or as determined by the Engineer.

Any pipe that cannot be repaired to its original condition or is damaged in jacking operations shall be removed and replaced at the Contractor's expense. Jacking pits shall be backfilled immediately upon completion of jacking operations.

Excavation for "Boring" pits and installation of shoring shall be as outlined under "Jacking." Boring operations may include a pilot hole which shall be bored the entire length of crossing and shall be used as a guide for the larger hole to be bored. Water or drilling fluid may be used to lubricate cuttings. Variation in line and grade shall apply as specified under "Jacking."

2.2.18.2. Tunneling: Tunneling may be used when the size of the proposed pipe would make the use of tunneling more satisfactory than "Jacking" or "Boring." The excavation for pits and the installation of shoring shall be as specified under "Jacking." The lining of the tunnel shall be of the material shown on the plans.

Access holes for grouting annular space shall be spaced a maximum of 10 feet.

2.2.18.3. Joints: Joints for pipe for "Jacking," "Boring," or "Tunneling," shall be as specified in "Water Mains", or as shown on the project plans or shop drawings as per pipe manufacturer's recommendation.

2.2.18.4. Grouting of Bores or Tunnels: Annular Space between casing pipe and limits of excavation (borehole) shall be pressure grouted, unless otherwise specified on the plans.

2.2.19. Cutting-in Valves.

The work involved in cutting a valve into an existing main is to consist of excavation and backfilling with approved selected material; hauling and disposition of surplus excavation and other materials; installation of the valve, valve box assembly, all pipe cut used to complete cut-in; reaction blocking; polyethylene wrapping where required.

2.2.20. Tapping Sleeves and Valves.

Size on size taps is not permitted. The work involved in the installation of a tapping sleeve and valve is to consist of excavation, backfilling the excavation with approved selected material, installing the tapping sleeve, reaction blocking, tapping valve, valve box assembly, concrete collar where subjected to street traffic, and a cast iron lid. New taps will not be permitted closer than 2 feet of a joint or existing tap. The use of a shell type cutter shall be required with tapping sleeves and valves. Whenever working on potable or recycled water system, disinfect the shell cutter with bleach prior to start of work. The cutting edge is to be sharp and round. Inspector will reject defective cutters.

Air test tapping sleeves to 50 psi prior to tapping main line.

Place valve box in such a manner to prevent shock or stress from being transmitted to valve. Center valve box over valves operating nut with box cover flush with finished pavement surface or located at another level as directed by Engineer. Valve boxes located in street or other areas subject to vehicular traffic shall be provided with concrete collars as shown on plans. Form collars around such valve boxes and finish off neatly and in a workmanlike manner.

2.2.21. Cutting-in Tees.

The work involved in cutting in a tee is to consist of excavation, shut-down and isolation of existing main to which the new main is to be connected, cutting pipe for connection, dewatering the excavation, customer notification of service interruption where required, installation of all pipe used to complete the connection, all necessary tie-ins (connection to existing or new main), fittings, approved reaction blocking required and backfilling the excavation with approved selected materials or flowable backfill if required. Where the installation of a valve is required, payment will be for valve accordance with this specification.

2.2.22. Pipe Joint Restraint System.

Pipe joint restraints shall be utilized to prevent movement for PVC push-on bell and spigot pipe connections. The restrainer may be adapted to connect a plain end PVC pipe to a ductile iron mechanical joint (MJ) bell fitting. Joint restraint is to be non-directional and installed to fully restrain system.

2.2.23. Concrete Encasement, Cradles, Saddles and Collars.

Concrete Encasement. When concrete encasement is shown on the plans or when directed, the trench is to be excavated and fine graded to a depth conforming to the details and sections shown on the plans. The pipe is to be supported by pre-cast concrete blocks of the same strength as the concrete for encasement and securely tied down to prevent floatation. Encasement concrete is to be placed to a depth and width conforming to details and sections shown on the plans.

Concrete Cradles. When concrete cradles are shown on the plans or when directed, the trench is to be prepared and the pipe supported in the same manner as described in Concrete Cradles, of this Section. The cradle shall be constructed in accordance with details and sections shown on the plans. Strap/Tie Downs shall be No. 4 rebar diameter minimum or better as determined by the Engineer.

Concrete Saddles. When shown on the plans or when directed, pipe to receive concrete saddle is to be backfilled in accordance with Section 3.D. of this specification to the spring line and concrete placed for a depth and width conforming to details and sections shown on the plans.

Concrete Collars. When shown on the plans or when directed, concrete collars are to be constructed in accordance with details and sections shown on the plans.

3.3 Fire Hydrants and Miscellaneous Appurtenances.

2.3.1. Fire Hydrants.

Hydrants are to be connected to the main as shown on the plans or as directed by the Engineer. They are to be installed in a manner which will provide complete accessibility and in a sage location where there is a minimum possibility of damage from vehicles or injury to pedestrians.

When the hydrant is placed directly behind the curb, the hydrant barrel is to be set so that no portion of the hydrant will be less than 12 inches nor more than 7-ft. from the back of the curb.

When the hydrant is set in the lawn space between the curb and the sidewalk or between the sidewalk and the property line, no portion of the hydrant or nozzle cap is to be within 6-in. of the sidewalk. Setting final grade of fire hydrants to match proposed or existing field conditions is the responsibility of the contractor.

Hydrants are to be set in accordance with plans and details are to be set plumb and are to have their nozzles parallel with or at right angles to the curb with the pumper nozzle facing the curb. Drainage and concrete pad are to be provided at the base of the hydrant as shown on the plans. No fire hydrant drainage system or pit is to be connected to a storm sewer or to a sanitary sewer.

2.3.1.1. **Restrained Joints:** Restrained mechanical joints that require field welding or groove cuts into the pipe barrel for restrain will not be accepted. Restrained joints shall be furnished for pipe at all changes in direction at indicated on plans, details, or as directed. Restrained mechanical joints shall be locked mechanical joints. Joints shall be capable of test pressure twice the maximum sustained working pressure of 350 psi for ductile iron pipe and PVC.

2.3.1.2. **Replacing and Relocating Existing Fire Hydrants:** When existing fire hydrants are to be replaced or relocated, the work is to be accomplished by either of the following:

2.3.1.2.1. Cutting or installing a tee of the size and type indicated on plans or as directed.

2.3.1.2.2. Using a tapping sleeve and valve of the size and type indicated on plans to install a new fire hydrant to an existing or new water main. Size on size taps is not permitted.

2.3.1.2.3. Relocating the existing fire hydrant by closing the existing fire hydrant, extending the fire hydrant branch and installing the existing fire hydrant as specified herein.

- 2.3.1.3. Salvage the existing fire hydrant and other materials as designated in the field by the Inspector and deliver to Water System Utility Owner at a location determined by the Engineer. Fire hydrant branches are to be abandoned by cutting and capping fire hydrant cast iron tee at the service main and surface restored to its original condition.
- 2.3.1.4. After the fire hydrant has been set, paint hydrant with suitable primer and finish with oil-based aluminum paint from top of hydrant to a point 18-20 inches below center line of the pumper nozzle and apply to all exposed metal surfaces above the hydrant base flange. The payment for fire hydrant painting is to be included in the unit cost for installing the fire hydrant.
- 2.3.1.5. Pipe, fittings, and valves used in the placement of fire hydrants and connections to the main are to be considered subsidiary to the fire hydrant installation and not a part of the main construction and will not be paid for directly.

2.3.2. Valve Boxes, Adjustments.

Valves are to be provided with valve boxes, manholes, or valve pits as shown on the plans.

The valve box is to be placed in such a manner to prevent shock or stress from being transmitted to the valve. It is to be centered and set plumb over the operating nut of the valve with the box cover flush with the surface of the finished pavement or at such other level as may be directed. Valve boxes located in streets or other areas subjected to vehicular traffic are to be provided with concrete collars as shown on the plans. Collars around such valve boxes are to be formed and finished off neatly.

Valve box is to be located so that the valve operating nut is readily accessible for operation through the opening in the valve box. The valve box is to be set flush with the surface of the finished pavement or at such other elevations as may be specified. Pits are to be constructed to permit minor valve repairs and to afford protection to the valve and pipe from impact where they pass through the pit walls.

Existing valve boxes located within the limits of new street construction which are in conflict are to be adjusted to match proposed finish grades.

Valve boxes installed as part of a new valve and mainline construction project are considered "new valves." Adjustments to "new valves" are incidental to the installation of the valve. No separate pay will be given to adjust "new valves" to finished grade.

2.3.3. Air Release Assembly.

Air release valves and appurtenant items are to be installed at the locations shown on the plans unless otherwise directed.

Install air release assemblies in open trench in accordance with plans and details. Assemblies include the valve, valve box, tapping saddle, pipe fittings, accessories and appurtenances. It also includes service line and tap to main. Air release assemblies installed in parkways or easements and outside of street pavement shall be installed in accordance with plans.

Air release assemblies installed on steel pipe attached to bridge structure includes the outlet on the steel pipe, valve, valve box, pipe fittings, security enclosure, accessories and appurtenances.

2.3.4. Blow-offs.

Permanent and temporary blow-off assemblies are to be installed at the locations shown on the plans or where otherwise directed. The permanent blowoff is to consist of all galvanized pipe, valve, and fittings of the various sizes detailed on the plans, 6-in. valve box assembly including the 6-in. valve box and concrete collar around the valve box where subjected to vehicular traffic. The temporary blowoff is to consist of all

galvanized pipe, valve, and fittings of the various sizes detailed on the plans. Valve box is to be raised on installed to finished grade in accordance with details.

2.3.5. Buried Gate and Butterfly Valves

Valve installation shall include; valve, reaction blocking when required conforming to plans, cast iron boot, valve box extension (Ductile Iron Riser Pipe), valve box, concrete collar where subjected to vehicular traffic, and valve box lid. Valves constructed in terrace shall be constructed with No. 3 bars all around.

The valve box shall be placed in such a manner to prevent shock or stress being transmitted to the valve. All valves located 6 feet and deeper shall include valve key extensions inside the valve box. The Contractor has the option to install fully adjustable valve box and valve key extension systems, on all valves located between 6 feet and 13 feet. Adjustable valve box and valve key extension systems shall be centered over the valve's operating nut with the box cover flush with the finished pavement surface or located at another level as directed by the Engineer. Valve boxes located in streets or other area subject to vehicular traffic shall be provided with concrete collars as shown in plans. Collars around such valve boxes shall be formed and finished off neatly and in a workmanlike manner.

Valve pits shall be located so that the valve operating nut is readily accessible for operation through the opening in the valve box. The valve box shall be set flush with the finished pavement surface or at other finish elevations as may be specified. Pits shall be constructed in such a manner to permit minor valve repairs and provide protection to the valve and pipe from impact where penetrating through pit walls. In a High Pressure Distribution System as specified in this specification, all valves 6 inches and larger, shall be supported on a concrete pad in accordance with plans.

2.3.6. Anchorage and Blocking.

Suitable reaction blocking or anchorage is to be provided at all dead ends, plugs, caps, tees, crosses, valves and bends as shown on the plans. All mechanical restraints are to be bidirectional. Anchor blocks are to be constructed solidly behind the fitting and symmetrical with the axis of resultant thrust except where this is not possible as in the case of gravity anchorage for vertical bends. Special ties and anchor fittings may be utilized in conjunction with blocking when shown on the plans or as directed.

Thrust blocking is to be a minimum of Class "A" (3,000 psi), concrete placed between solid ground and the fitting except as otherwise shown on the plans. The area of bearing in contact with solid ground is to be that shown on the plans or as directed.

All thrust blocking placed in conjunction with mains and appurtenances constructed in accordance with standard details provided in the construction drawings. In all cases, the design of thrust blocking shall be of sufficient size to withstand a soil pressure of 3000 psf, unless specified otherwise in the job plans or specifications. The maximum soil pressure value that will be allowed for the design of thrust blocking shall be 5000 psf. When soil pressure bearing values of 4000 psf or 5000 psf are recorded for design of thrust blocks, copies of soil tests made for determining the bearing value of the soil in question shall be submitted to the Engineer for verification.

The blocking is to be placed so that pipe and fitting joints will be accessible. Pipe polywrap is to be placed between the pipe or fitting and the concrete.

The reaction block on the unused branch of a tee is to be poured separately from the block across the back of the tee. If they are poured simultaneously, a rigid partition is to be placed between the blocks.

Valves 12-in. and larger in size are to be supported on a concrete pad extending vertically from 12-in. below the bottom of the valve to the lower quarter point of the hub and laterally from face to face of hubs and transversely from wall to wall of the trench.

3.4

Backfill.

2.4.1. Initial Backfill.

Initial backfill is defined as backfill having a thickness in its compacted state from the surface of the bedding to a point 1 foot above the top of pipe. The first lift of initial backfill is to be inspected and approved prior to placement of the second lift. The second lift of initial backfill material is to extend from the spring line of the pipe with a minimum of one foot above the top of the pipe. The second lift is to be evenly spread in a similar manner as the first lift.

For diameters 24 inches and larger, simultaneously spread initial backfill material alongside, under the lower quadrant of pipe and over the pipe in 12 inch lifts to a point sufficient to a minimum of 1 foot above the top of pipe.

Consolidate initial backfill material to assure it is incorporated. A handheld vibrator, commonly used for concrete work, can be used for this purpose. The vibrator shall be inserted every 3 feet on each side of pipe.

2.4.2. Secondary Backfill.

Secondary backfill is defined as backfill from 1 foot above the top of pipe to the top of the trench. Secondary back fill is to be constructed in accordance with details shown on plans and these specifications.

Secondary backfill material shall be placed in maximum 12 inch loose lifts or as directed.

2.4.3. Sand Backfilling of Cross Trenches and Open Holes.

Blow-offs, tie-ins, air release valves, and service lines, meter boxes, or other specials are to be backfilled with sand and thoroughly consolidated by saturating with water, unless otherwise directed. The use of mechanical tamping equipment for compaction of backfill will not be permitted at such locations. Disposal of surplus excavated material and placement of sand is to be considered subsidiary to trenching and backfilling and will not be paid for directly.

2.4.4. Trench Backfill Across Traffic Arteries.

Any trench in or across traffic arteries is to be backfilled immediately after the pipe is installed unless the Engineer determines unusual conditions exist that render immediate backfilling unfeasible.

2.4.5. Flowable Backfill.

Instead of normal backfill materials, the Contractor is to backfill the trench with flowable backfill with fly ash material at the locations shown on the plans and/or at locations directed. The flowable backfill material and operation is to be in accordance with Item 401, "Flowable Backfill".

3.5 **Flushing and Testing Mains.**

2.5.1. Flushing.

Immediately upon completion of pipe laying, the Contractor is to flush all mains. This flushing is to be at the direction of the Engineer and is to consist of completely filling sections of main between valves and then displacing such initial volumes of water by introducing clear water from existing facilities into and through the main to the point of discharge from the main being flushed.

The flow-through is to continue until the Engineer determines all dust, debris, or foreign matter that may have entered during pipe laying operations has been flushed out. The new line is to then be left under system pressure for testing.

To avoid damage to pavement and inconvenience to the public, fire hoses are to be used to direct flushing water from the main into suitable drainage channels or sewers.

2.5.2. Operation of Valves.

No valve in the distribution system is to be operated by the Contractor without prior permission. The Contractor is to notify the utility owner when a valve is to be operated and is to only operate the valve in the presence of the Engineer's representative.

2.5.3. Hydrostatic Tests.

Except in high pressure sections of the water distribution system where test pressures will exceed 150 psi, all new mains are to be hydrostatically field tested at a maximum test pressure of 150 psi before approval by Engineer. Where designated as "high pressure area," all new mains shall be hydrostatically field tested at a maximum test pressure of 200 psi before acceptance by the Engineer. All joints which are found to leak either by observation or during any test are to be made watertight by the Contractor. In case repairs are required, the hydrostatic field test is to be repeated until the pipe installation conforms to the specified requirements and is acceptable. The expense for tests which meet specified requirements is to be made in accordance with the unit price for the hydrostatic pressure test. No payment is to be made for tests which fail to meet specified test leakage requirements.

After the new main has been laid and backfilled as specified, but prior to chlorination and replacement of pavement, it is to be filled with water for a minimum of 24 hours and then subjected to a hydrostatic pressure test. The specified test pressure is to be supplied by means of a pump connected to the main in a satisfactory manner. The pump, pipe connection, and all necessary apparatus including gauges and meters are to be furnished by the Contractor. Unless otherwise specified, the Water System Company will furnish water for filling lines and making tests through existing mains.

Before applying the specified test pressure, all air is to be expelled from the main. To accomplish this, taps are to be made, if necessary, at the points of highest elevation and afterwards tightly plugged at no cost to the Department or the Water System Utility Owner. At intervals during the test, the entire route of the new main is to be inspected to locate any leaks or breaks. If any are found, they are to be stopped or repaired. The test is to be repeated until satisfactory results are obtained.

The hydrostatic test is to be made so that the maximum pressure at the lowest point does not exceed the specified test pressure. The duration of each pressure test is to be a minimum of 4 hours for new mains in excess of 1,000-ft. and a minimum of 1 hour for new mains less than 1,000-ft after the main has been brought up to test pressure. The test pressure is to be measured by means of a tested and properly calibrated pressure gauge acceptable to Engineer. All pressure tests are to be continued until the Engineer is satisfied that the new main meets the requirements of these specifications. Should any test of pipe in place disclose leakage greater than listed in Table 22 or 23, Hydrostatic Test Leakage Allowances, the Contractor is to, at his expense, locate and repair the defective joints until the leakage is within the specified allowance. Leakage is defined as the quantity of water supplied into the newly laid main, or any valve section of it, necessary to maintain the specified leakage test pressure after the main has been filled with water and the air expelled. The Contractor is to notify the Engineer prior to beginning the test, and the Water System Company's Inspector is to be present during the pressure test.

PVC pipe leakage allowances shall conform to DI leakage allowances listed on Tables 22 and 23, Hydrostatic Test Leakage Allowances.

Table 22

Hydrostatic Test Leakage Allowance (Maximum) @ 150 psi

Pipe	100	200	300	400	500	600	700	800	900	1000	2000	3000	4000	5000
6"DI*	0.11	0.22	0.33	0.44	0.55	0.66	0.77	0.88	0.99	1.10	2.20	3.30	4.40	5.50
8"DI*	0.15	0.29	0.44	0.59	0.74	0.88	1.03	1.18	1.32	1.47	2.94	4.41	5.88	7.35
12"DI*	0.22	0.44	0.66	0.88	1.10	1.32	1.54	1.76	1.98	2.20	4.40	6.60	8.80	11.00
16"DI*	0.29	0.59	0.88	1.18	1.47	1.76	2.06	2.35	2.65	2.94	5.88	8.82	11.76	14.70
20"DI*	0.39	0.74	1.10	1.47	1.84	2.21	2.55	2.94	3.31	3.68	7.63	11.04	14.72	18.40
20"CSC	0.08	0.16	0.24	0.32	0.40	0.47	0.55	0.63	0.71	0.79	1.58	2.37	3.16	3.95
24"DI*	0.44	0.88	1.32	1.76	2.21	2.65	3.09	3.53	3.97	4.41	8.82	13.23	17.64	22.05
24"CSC	0.10	0.19	0.29	0.38	0.48	0.57	0.67	0.76	0.86	0.95	1.90	2.85	3.80	4.75
30"DI*	0.55	1.10	1.66	2.21	2.76	3.31	3.86	4.42	4.97	5.52	11.04	16.56	22.08	27.05
30"CSC	0.12	0.24	0.35	0.47	0.59	0.71	0.83	0.94	1.06	1.18	2.36	3.54	4.72	5.90
36"DI*	0.66	1.32	1.99	2.65	3.31	3.97	4.63	5.30	5.96	6.62	13.24	19.86	26.48	33.10
36"CSC	0.14	0.28	0.43	0.57	0.71	0.85	0.99	1.14	1.28	1.42	2.84	4.26	5.68	7.10
42"DI*	0.77	1.54	2.32	3.09	3.86	4.63	5.40	6.18	6.95	7.72	15.44	22.16	30.88	38.60

Table 22

Hydrostatic Test Leakage Allowance (Maximum) @ 150 psi

Pipe	100	200	300	400	500	600	700	800	900	1000	2000	3000	4000	5000
42"CSC	0.17	0.33	0.50	0.66	0.83	1.00	1.16	1.33	1.49	1.66	3.32	4.98	6.64	8.30
48"DI*	0.88	1.77	2.65	3.53	4.42	5.30	6.18	7.06	7.95	8.83	17.66	26.16	35.32	44.15
48"CSC	0.19	0.38	0.57	0.76	0.95	1.13	1.32	1.51	1.70	1.89	3.78	4.98	6.64	8.30
54"CSC	0.21	0.42	0.63	0.84	1.05	1.26	1.47	1.68	1.89					
60"CSC	0.24	0.48	0.72	0.96	1.20	1.44	1.68	1.92	2.16					

* DI Pipe includes mechanical and push-on joints.

** GPH for CSC Pipe are manufacturer's maximum.

Note: Leakage allowances may be determined for footages not specifically listed by interpolation and/or by the combination of various tabular data.

Table 23										
Hydrostatic Test Leakage Allowances (Maximum) @ 200 psi										
Nom	Allowable Leakage in Gallons Per Hour (GPH) **									
Dia-Ty	Pipe Length in Feet									
Pipe	100	200	300	400	500	600	700	800	900	1000
6"DI*	0.13	0.25	0.38	0.51	0.64	0.76	0.89	1.02	1.14	1.27
8"DI*	0.17	0.34	0.51	0.68	0.85	1.02	1.19	1.36	1.53	1.70
12"DI*	0.26	0.51	0.77	1.02	1.28	1.53	1.79	2.04	2.3	2.55
16"DI*	0.34	0.68	1.02	1.36	1.7	2.04	2.38	2.72	3.06	3.40
20"DI*	0.43	0.85	1.28	1.70	2.13	2.55	2.98	3.40	3.83	4.25
20"CSC	0.08	0.16	0.24	0.32	0.4	0.47	0.55	0.63	0.71	0.79
24"DI*	0.51	1.02	1.53	2.04	2.55	3.06	3.57	4.08	3.59	5.10
24"CSC	0.10	0.19	0.29	0.38	0.48	0.57	0.67	0.76	0.86	0.95
30"DI*	0.64	1.27	1.91	2.55	3.19	3.82	4.46	5.10	5.73	6.37
30"CSC	0.12	0.24	0.35	0.47	0.59	0.71	0.83	0.94	1.06	1.18
36"DI*	0.76	1.53	2.29	3.06	3.82	4.58	5.35	6.11	6.88	7.64
36"CSC	0.14	0.28	0.43	0.57	0.71	0.85	0.99	1.14	1.28	1.42
42"DI*	0.89	1.78	2.68	3.57	4.46	5.35	6.24	7.14	8.03	8.92
42"CSC	0.17	0.33	0.5	0.66	0.83	1.00	1.16	1.33	1.49	1.66
48"DI*	1.02	2.04	3.06	4.08	5.1	6.11	7.13	8.15	9.17	10.19
48"CSC	0.19	0.38	0.7	0.76	0.95	1.13	1.32	1.51	1.7	1.89
54"CSC	0.21	0.42	0.63	0.84	1.05	1.26	1.47	1.68	1.89	2.10
60"CSC	0.23	0.46	0.69	0.92	1.15	1.38	1.61	1.84	2.07	2.30

* DI Pipe includes mechanical and push-on joints.

** GPH for CSC Pipe are manufacturer's maximum.

Note: Leakage allowances may be determined for footages not specifically listed by interpolation and/or by the combination of various tabular data.

3.6

Disinfection of New Mains Utilizing Machine Chlorination.

After the new mains have successfully passed the pressure test specified herein, Section 3.E.3, "Hydrostatic Tests" the Contractor shall disinfect mains as shown on the plans or otherwise directed as "Machine Chlorination". This disinfection is to include chlorination, flushing, and placing the mains in service. All other disinfection requirements shall also be accomplished by the Contractor.

2.6.1.

Operation of Valves.

During and after the disinfection of mains, the Contractor will be notified by the Engineer sufficiently in advance to enable the Contractor to have a competent representative present whenever valves are to be operated that will affect the pressure in any part of the work for which the Contractor is responsible.

2.6.2.

Contractor's Personnel and Equipment.

The Contractor is to supply labor and equipment necessary to make all excavations required for chlorination, equipment connections, subsequent flushing, and placing the mains in service.

2.6.3. Safeguarding and Backfilling Open Holes.

The Contractor is to be responsible for safeguarding any open holes excavated or left open for flushing and disinfection purposes. Following completion of disinfection, the Contractor is to backfill such holes in accordance with appropriate provisions of Section 3.D, "Backfill".

2.6.4. Disinfection of Mains Utilizing Dry Calcium Hypochlorite.

Mains are to be disinfected with dry calcium hypochlorite (HTH) where shown on the plans or as directed and shall not exceed a total length of 800 feet. This method will also be followed for main repairs. Contractor shall utilize appropriate safety measures to protect personnel during disinfection operation.

2.6.5. Dosage.

The Contractor is to disinfect the new or replaced mains with calcium hypochlorite (HTH) of 70 percent available chlorine. Sufficient calcium hypochlorite (HTH) is to be used to obtain a minimum chlorine concentration of 50 ppm. The following Table 24, Chlorine Dosage, is included for the convenience of the Contractor:

Table 24	
Chlorine Dosage	
Diameter of Pipe Inches	Ounces Per Foot To Obtain 50 ppm Chlorine Dosage
6	0.0138
8	0.0233
10	0.0364
12	0.0523
14	0.0708
16	0.0934
18	0.1175
20	0.1455
24	0.2080
30	0.3270
36	0.4690
42	0.6370
48	0.8330
54	1.0575
60	1.308

A heaping tablespoon holds approximately 1/2 ounce, and a standard measuring cup holds approximately 8 ounces.

2.6.6. Filling the Main.

Those sections of main to which dry calcium hypochlorite (HTH) has been applied is to be filled slowly to allow for the even distribution of the disinfecting material. The manipulation of valves is to be under the direction of the Engineer in accordance with Section 3.F.1, "Operation of Valves".

2.6.7. Holding Time.

The length of time that sections of main disinfected with calcium hypochlorite (HTH) is to be allowed to stand undisturbed will depend upon the particular job and Texas Commission on Environmental Quality (TCEQ) criteria.

When circumstances permit a shutdown with no customers out of service, the required minimum detention time will be 24 hours with a 50 ppm chlorine dosage.

When customers are out of service during a shutdown with no leakage past valves, the required minimum detention time will be 3 hours and the chlorine dosage will be 300 ppm.

When customers are out of service during a shutdown with some leakage past valves, the required minimum detention time will be 30 minutes with a 500 ppm chlorine dosage.

2.6.8. Flushing.

Following the expiration of the specified holding time, the treated section of main is to be flushed thoroughly by the Contractor in accordance with the applicable provisions of Section 3.E, "Flushing and Testing Mains". Flushing is to continue until no chlorine remains detectable by taste or odor or until the chlorine residual is less than 0.3 ppm. The Contractor must make provisions for the disposal and runoff of the flushing operations in order to minimize erosion or impact to residents.

2.6.9. Preventing Reverse Flow.

Valves are to be manipulated so that the strong chlorine solution in the line being treated will be flushed out of the main and will not flow back into the line supplying the water.

2.6.10. Supervision.

All disinfection is to be done as directed by the Engineer.

2.6.11. Additional Treatment.

Should the new main fail to meet minimum public health standards for bacteriological quality after flushing, further treatment is to be as directed. If further disinfection is required, chlorination is to be done in accordance with Section 3.F, "Disinfection of New Mains Utilizing Machine Chlorination". In no case, however, is the new line to be acceptable as complete and satisfactory until the bacteriological quality of the water taken from the main meets the Standards of the TCEQ.

If an open hole is unsafe and does not have proper trench protection, owner's chlorination crew will not chlorinate project until acceptable trench protection is provided.

2.6.12. Safeguarding and Backfilling Open Holes.

The requirements for safeguarding and backfilling all holes excavated or left open for chlorinating and sampling is to be as specified in Section 3.F.3, "Safeguarding and Backfilling Open Holes".

3.7 **Service Supply Lines.**

Service supply lines and fittings, meter boxes and appurtenances shall conform to material specifications and shall be installed by the contractor as specified herein, or as directed by the engineer and in accordance with plans.

2.7.1. Designation of Service Supply Lines: A service supply line located between the Water main and the inlet side of the water meter is designated as a "water service line". A service supply line located between the outlet side of the water meter to the point of connection within the limits of the Customers lot or property is

designated as "Customer's yard piping". Services 2" and smaller are designated "small services"; services 4" and larger are designated "large services".

- 2.7.2. Service Relays: New transfer main(s) to which services are to be relayed and are on the same side of the streets as the Customer's meter are defined as "short relays". New transfer main(s) to which services are to be relayed and are on the opposite side of the street from the Customer's meter are defined as "long relays".

Service Reconnects: New transfer main(s) to which services are to be reconnected and on the same side of the street as the old main are defined as "service reconnects".

Existing services on the opposite side of the street to the new main shall be defined as a "long relay".

- 2.7.3. Service Relocates: Service Relocates are defined as services that are relocated from an alley to a side or front street. New transfer main(s) to which services are to be relocated and are on the same side of the street as the Customer's new meter box location, are designated as "short relocates". New transfer main(s) to which services are to be relocated and are on the opposite side of the street from the Customer's new meter box location, are designated as "long relocates".

- 2.7.4. New Services: If a new main is required to be extended to provide water service for new Customers, the service lines laid to the new main shall be designated as "new services." New laid main(s) to which new services are on the same side of the street as the Customer's new meter box location, are designated as "new short services." New laid main(s) to which new services on the opposite side of the street from the Customer's new meter box location, are designated as "new long services."

- 2.7.5. New Un-metered Services: New Un-metered services are defined as services that are installed on existing mains or new mains to provide service to Customers platted vacant lots. Where the new main or existing main to which new un-metered services are being installed is on the same side of the street as the Customer's new or existing meter box location, (Inspector to set location of new meter box if no existing meter box is set), the services to be laid are designated "new un-metered short services." Where the new main or the existing water main to which new un-metered services are installed is on the opposite side of the street from the Customer's new or existing meter box location, (Inspector to set location of new meter box if no existing meter box is set), the services to be laid are designated "new un-metered long service". New un-metered long services and new un-metered short services will not include "Customer's yard piping" and no meter will be set.

- 2.7.6. Tap Holes: Tap holes are defined as excavations at existing mains, which are required in association with replacements of water service lines by pulling, boring or jacking operations.

All backfill material shall be as specified for main and service line trench excavation.

For service lines and tap holes, payment for bedding, initial backfill and secondary backfill shall be included in the various sizes of each service placed.

- 2.7.7. Service Line Installation: Unless otherwise notified, service relays, service reconnects, service relocates and new services shall be installed as described herein, and in plans. Unless otherwise indicated, existing meter and meter box relocation shall be included in the service line installation.

All service line installation shall include a dielectric union to be installed within the meter box on the outlet side of the meter, as shown in plans.

Cutting, excavation, backfill and replacement of pavement shall be done as specified herein and in accordance with applicable sections of this specification and the contract documents. The minimum trench width for small service lines shall be 8 inches, while the minimum trench width for large service Lines shall be the nominal pipe diameter plus 16 inches, except when specified otherwise by the Engineer. For $\frac{3}{4}$ " to 2" Service lines, minimum bury depth shall be 3 feet. For services greater than 2", minimum depth of bury shall be 4 feet.

All service lines shall be installed in accordance with plans, and specifications.

The Contractor shall use precaution to protect and preserve the polyethylene wrap around Ductile-Iron (DI) water mains when installing service corporations. The required method is, wrap pipe tape around the pipe, over the polywrap, in the area to be tapped. The tap shall be made through the tape and polywrap. It is not necessary to remove and replace polywrap. All exposed pipe, corporation and the first three feet of the service, shall be wrapped and taped to achieve a complete seal. In addition, a sand envelope shall extend over and around the connection to a depth of 8 inches above the main.

Small service lines shall be embedded in sand in accordance with specification

Where approved by the Inspector, the Contractor may lay the new service line from the corporation stop to the curb stop or angle valve. Upon completion, the Contractor shall isolate the new service line by closing the curb stop or angle valve until the meter box is set.

- 2.7.8. Splicing: A long service line single splice may be permitted by means of a 3-part compression or flared coupling only when approved in advance by the Engineer, provided the location of the splice is not under pavement or concrete. The segment added is required to be the same material as the existing service line, unless otherwise directed by the Engineer. Splicing short service lines will not be permitted.
- 2.7.9. Boring or Jacking Service Lines: Service lines which cross paved streets may be installed at the Contractor's option by boring or jacking operations. Where it becomes necessary to widen the main trench section to accommodate a bore pit, such widening shall not extend more than one additional foot into the traffic side of the street.
- 2.7.10. Tapping Asbestos Cement (AC) Water Mains: All necessary service line tapping of AC pipe shall be completed during the period immediately before or after hydrostatic pressure testing operations so that subsequent flushing will maximize the elimination of contaminants associated with the tapping process.
- Tapping of AC pipe must be done in accordance with manufacturers' recommendation and done only with tap machine having a built in flush valve and the flush valve must be open during the entire procedure.
- 2.7.11. Abandonment of Service Lines: The Contractor shall accomplish all cutting, capping, and plugging necessary to isolate new service lines transferred to new and existing mains from those abandoned, including service lines designated on the plans as "tap plug" and "tap kill." The corporation stop for an abandoned service line tapped on a ferrous main shall be removed, and the tap at the main shall be plugged with an appropriately sized brass plug. For a non-ferrous main, the corporation stop shall not be removed from the main. Instead, the corporation stop shall be closed and the flared nut shall be removed from the corporation stop. After the appropriately sized copper disc is inserted inside the flared nut, replace the flared nut on the corporation stop. The Contractor shall salvage copper service line tubing, brass fittings, and other materials as directed by the Inspector and return them to the Owner.
- 2.7.12. Tapping PVC (C-900): Tapping of PVC must be done in accordance with Uni-Bell procedures. Direct Tapping will not be allowed. All drill cutting tools must be the "shell type" with internal teeth or double slots which will retain the coupon.
- The shell cutters must be designed for C-900 pipe, thus having sufficient root depth to handle the heavier walled pipe.
- 2.7.13. Small Service Lines: Copper tubing shall be used for ¾" through 2" service lines. Brass fittings for ¾" and 1" service lines shall be of the flared or compression type for the use with Type 'K' soft annealed copper tubing. Brass fittings for 1½" and 2" lines shall be of the flared or compression type for use with type 'K' soft annealed copper tubing, except as modified by this specification.

Copper tubing shall be cut squarely by using an approved cutting tool and by avoiding excessive pressure on the cutting wheels which might bend or flatten the pipe walls. Following the copper tubing cut, but before flaring, a reamer shall be used to remove the inside rolled lip from the tubing. Flared ends shall be expanded

by the use of a flaring tool using care to avoid splitting, crimping, or overstressing the metal. Pipe adjacent to the fittings shall be straight for at least 10 inches. Bending of tubing shall be accomplished by using an appropriate sized bending tool. No kinks, dents, flats, or crimps will be permitted, and should such occur, the damaged section shall be cut out and replaced. When compression fittings are used, the copper tubing shall be cut squarely prior to insertion into the fitting. Final assembly shall be in accordance with the manufacturers recommendations.

- 2.7.14. Small Service Lines on New Mains: Installation of new copper service lines shall consist of all excavation through miscellaneous material encountered; trench excavation protection; drilling and tapping the new main with an approved tapping machine; setting the curb stop or angle valve at the meter; laying the new copper service line at the specified depth between the main and the meter and its tie-in at the corporation and the curb stop or the angle valve; relocating the existing meter and installing a new meter box where required in accordance with this specification, herein; backfilling the trench with approved selected material and disposal of surplus excavated material; capping the tap hole with asphalt treated base, including the outer limits of the main trench line with service line trench; cutting and replacing pavements, curbing and sidewalks of all types over the limits of the main line trench and the completed service line trench.

- 2.7.15. Reconnecting Service Lines: Both old and new water mains at existing service line connections as shown on the plans shall be exposed. The old main shall be exposed for the purpose of gaining access to the existing service corporation stop and the new main for the purpose of installing the new corporation stop. The new main shall be exposed for the purpose of being drilled and tapped with an approved tapping machine, a new corporation stop installed under pressure, and the trench extended laterally to expose a sufficient length of the existing service line to provide slack to bend it to position for tying to the new corporation stop. After suitable notification to the Customer, the Contractor shall "kill" the existing service by closing the corporation stop, removing the existing flare nut, inserting the existing flared nut on the corporation stop if the main is non-ferrous, or plugging the existing service line at the main if the main is ferrous. The Contractor shall then immediately open the stop and restore water service to the Customer. Where it is not possible to obtain sufficient length in the existing service to tie directly to the new main, at the direction of the Engineer, the Contractor shall splice the necessary length of new tubing and tie it to the existing service by means of a compression coupling at a point as close as practicable to the new main.

Cutting and bending of the tubing, introduction of slack to compensate for soil movement, and completion of the installation shall be as specified in this specification.

Where old and new mains are on opposite sides of the street, service lines may be installed under the street pavement by boring rather than trenching.

- 2.7.16. Relaying Service Lines: The existing or new mains shown on plans shall be exposed opposite location stakes placed on site at the direction of the Engineer. The existing or new main shall be drilled and tapped with an approved tapping machine, a new corporation stop installed, and the trench extended laterally to the location specified for the meter box. The existing meter shall be reset and the meter box and base shall be installed at its staked location and perpendicular to the corporation stop in the water main. The meter box location shall not vary more than 24 inches in any direction from its staked location. The service line shall be installed with sufficient slack to compensate for soil movement. Where the location of the existing meter is not changed, the new service line shall be extended from the main to the existing meter, a new curb stop installed at the end of the service line, and connected to the inlet side of the meter. If disturbed, the existing meter box shall be reset to correct grade. Long service relays may be placed under the street pavement by boring or jacking rather than trenching.

- 2.7.17. Single Service Line - Dual Meters: The single service line - dual meter installation shall consist of a 1" copper service line reducing to two $\frac{3}{4}$ " copper service lines at a tee which shall be set in line with the front edge of meter boxes for $\frac{5}{8}$ " and $\frac{3}{4}$ " meters. A single service line with dual meters shall be installed in those new residential developments where new $\frac{5}{8}$ " and $\frac{3}{4}$ " meters are required and in main replacement work where it is necessary to change the location of existing $\frac{5}{8}$ " and $\frac{3}{4}$ " meters. Single service line - dual meter materials and installation requirements shall conform to requirements established herein.

- 2.7.18. Small Service Lines on Existing Mains: The work involved in the installation of new copper service lines on existing mains shall consist of jacking, boring, tunneling, and, where authorized, open trench operations all excavation through whatever material encountered; trench excavation protection; using the existing corporation when approved by the Engineer; tapping the existing main and installing the new corporation and setting the curb stop or angle valve at the meter; relocating the existing meter and installing a new meter box where required in accordance with this specification; abandoning the existing corporation stop, removing the existing flared nut, inserting inside the existing flared nut an appropriately sized copper disc and replacing the existing flared nut on the corporation stop if the main is non-ferrous, or plugging the existing service line at the main if the main is ferrous; installing the new service line at the same grade as the existing service line or at the specified grade between the main and the existing meter and its tie-in at the corporation and the curb stop; disposal of surplus excavated material; capping the tap hole with asphalt treated base including the outer limits of the main line trench and the service line trench; cutting and replacing all surfaces of whatever type encountered over the completed service line trench; restoration of the site.
- 2.7.19. Large Service Lines: DI pipe and cast-iron fittings used for metered service lines and non-metered fire service lines larger than 2" shall be installed in accordance with the applicable provisions of this specification, except where otherwise approved by the Engineer.
- 2.7.20. Large Service Lines on New Mains: Work involved in the installation of a new metered service lines and non-metered fire service lines shall consist of all excavation through whatever material encountered; trench excavation protection, installing tees, pipe and fittings of various sizes including main line and service line valves, valve boxes, DI pipe, fittings, in accordance with plans and reaction block required; backfilling with approved selected material; cutting and replacing pavements, curbing, and sidewalks of all types over the limits of the main line trench and the completed DI service line.
- 2.7.21. Large Service Lines on Existing Mains: The work involved in the installation of the new metered service lines and non-metered fire service lines shall consist of all excavation through whatever material encountered, trench excavation protection, cutting-in tees and installing tapping sleeves and valves, pipe and fittings of various sizes including main line and service valves; valves boxes, DI pipe, fittings and reaction block required; backfilling with approved selected material; cutting and replacing pavements, curbing, and sidewalks of all types over the limits of the main line trench and the completed DI service line.
- 2.7.22. Meter Boxes. Physical movement of existing meters and meter boxes to new locations may be required where service lines are transferred to new mains in conjunction with main replacement work. Unless specified otherwise, the Contractor shall move existing meters and meter boxes and reconnect and adjust customer's yard piping as part of transferring service lines. A dielectric coupling PVC schedule 80 shall be installed within the meter box between the meter and the customer's yard piping.
- Round and oval meter boxes with round covers shall be salvaged and returned to the Owner by the Contractor. The Contractor shall also replace the salvaged meter boxes with the new, appropriately styled oval plastic meter box with oval cover, or rectangular meter box. Unless otherwise specified, the old service line shall be abandoned after the existing meter has been reset in the existing or new meter box.
- Where meter boxes are installed in sidewalks or driveways, the Contractor shall install a number one meter box (2 pieces) as shown in the Specification and plans.
- New meters will be set by the Owner where mains are extended and new services lines are installed for new or initial customer service. In lieu of the new meter, the Contractor shall furnish and install a meter template in accordance with plans
- Meter and meter box configuration, shall have the meter set horizontal, approximately 6 inches below the top of meter box, so that the meter is above the bottom of the meter box and in line with the meter box lid opening. The top of the meter box shall be flush with the existing ground surface. All excess soil above the meter coupling, meter flange and meter nuts inside the meter box shall be removed so that the meter register is clearly visible. The Contractor shall exercise special precautions during excavation at the existing meter location in order to minimize the disturbance of the customer's yard piping. However, if the existing meter elevation is low, the Contractor shall raise the existing meter to conform to the correct configuration indicated

herein. Adjustment of meter to proper grade is incidental to the construction and will not be paid for separately.

Where required, pressure reducing valves shall be installed by the customer in accordance with the Uniform Plumbing Code and shall be placed beyond the outlet side of the meter, but not within the Owner's meter box. The pressure reducing valve shall be the property of the water user who will be responsible for its installation, maintenance, and replacement as required.

The meter box adjustment shall not exceed 10 linear feet from the existing box.

2.7.23. Water Service for Fire Lines

- 2.7.23.1. Start of Work: Three working days notice will be given to the Inspector prior to start of a project after permit has been issued. The Contractor shall start his work at a tie-in or point designated by the Engineer. Pipe shall be laid with bell ends facing in the direction of laying, unless otherwise authorized or directed by the Engineer. All valves and fire hydrants must be installed as soon as pipe laying reaches their established location. Pipe shall be installed to the required lines and grades with fittings, valves, and hydrants placed at the required locations. Spigots shall be centered in bells or collars, all valves and hydrant stems shall be set plumb, and fire hydrant nozzles shall face as shown on the plans or as directed by the Engineer. No valve or other control on the existing system shall be operated for any purpose by the Contractor unless a representative of the Water System Utility Owner is present.
- 2.7.23.2. Crossing Other Underground Lines: New fire line services crossing any other utilities shall have a minimum of 48 inches of cover over the top of the pipe unless otherwise waived or modified by the Engineer. Excavation around other utilities shall be done by hand for at least 12 inches all around. Any damage to other utilities shall be reported to their proper governing entity.
- 2.7.23.3. Pipe Grade: Fire line services shall have a minimum of 48 inches of cover for mains 16" and below, and 60 inches for mains 20" and above, over the top of the pipe unless otherwise waived or modified by the Engineer. Pipe grades shall be as required by the plans or as directed by the Engineer. Grades shall be met as specified. Precautions shall be taken to insure that the pipe barrel has uniform contact with the Modified Grade 5 for its full length except at couplings. Couplings shall not be in contact with the original trench bottom prior to backfilling. Bedding and initial backfill material shall be placed under the coupling and compacted by hand prior to backfilling so as to provide an even bearing surface under the coupling and pipe. Changes in grade shall be made only at joints.
- 2.7.23.4. Modified Grade 5 Materials: Prior to placing pipe in a trench, the trench shall have been excavated to the proper depth as required of these specifications. Approved new materials or Engineer approved materials selected from suitable fines derived from the excavation shall be smoothly worked across the entire width of the trench bottom to provide a supporting cushion.
- 2.7.23.5. Structures to Support Pipe: Where as the bottom of a trench at subgrade consist of material that is notably unstable by the Engineer and cannot be removed and replaced with approved material may be properly compacted in place to support the pipe. The Contractor shall also construct a foundation for the pipe consisting of piling, concrete beams, or other supports in accordance with plans prepared by the Engineer.
- 2.7.23.6. Lowering Materials into Trench: Proper implements, tools, and facilities satisfactory to the Engineer shall be provided and used by the Contractor for the safe and convenient completion of work. All pipe, fittings, valves, and hydrants shall be carefully lowered into the trench piece by piece, by means of a derrick, ropes, or other suitable tools or equipment in such a manner as to prevent damage to water service materials and protective coatings and linings. Under no circumstances shall water service materials, pipes, fittings, etc., be dropped or dumped into the trench. Extreme care shall be taken to avoid damaging polywrap films. No chains or slings shall be allowed unless the entire sling is wrapped with a protective nylon web sock.
- 2.7.23.7. Laying of Pipe: Every precaution shall be taken to prevent foreign material from entering the pipe during its installation. Under adverse trench conditions or otherwise required by the Engineer, a heavy, tightly woven canvas bag of suitably sized shall be placed over each of the pipe.

The Canvas bag shall be left in place until a connection is made to the adjacent pipe. The interior of each pipe shall be inspected for defects, and the pipe shall be rejected if any defects are found.

After placing a length of pipe in the trench, the jointed end shall be centered on the pipe already in place, forced into place, brought to correct line and grade, and completed in accordance with the requirements of these Specifications. The pipe shall be secured in place with approved backfill material tamped around it. Pipe and fittings which do not allow a sufficient and uniform space for joints shall be rejected and shall be replaced with pipe and fittings of proper dimensions. Precautions shall be taken to prevent dirt or other foreign matter from entering the joint space.

At times when pipe laying is halted, the open end of pipe in the trench shall be closed by a watertight plug or other means approved by the Engineer. Pipe in the trench which cannot temporarily be joined shall be capped or plugged at each end to make it watertight. This provision shall apply during all periods when pipe laying is not in progress. Should water enter the trench, the seal shall remain in place until the trench is pumped completely dry. The Contractor shall provide all plugs and caps of the various sizes required.

- 2.7.23.8. Deviations in Line or Grade: Wherever obstructions not shown on the plans are encountered during the progress of the work and interfere to an extent that an alteration in the plan is required, the Inspector shall have the authority to change the plans and direct a deviation from the line and grade or to arrange with the owners of the structures for the removal, relocation, or reconstruction of the obstructions. Any deviation from the line shall be accomplished by the use of appropriate bends unless such requirement is specifically waived by the Engineer.

Whenever it is necessary to deflect pipe from a straight line, the deflection shall be as directed by the Inspector and as described herein. In no case shall the amounts exceed those shown in Table 19 "Maximum Deflections of Ductile-Iron Pipe" for ductile-iron pipe

- 2.7.23.9. Cutting Pipe: The cutting of pipe for inserting valves, fittings, or closure pieces shall be accomplished in a neat manner so as to produce a smooth end at right angles to the axis of the pipe. The recommendations of the pipe manufacturer shall be strictly followed by the Contractor. Under no circumstances, shall a workman not equipped with proper safety goggles, helmet and all other required safety attire be permitted to engage in this work.

- 2.7.23.10. Asbestos-Cement (AC): No field cutting will be allowed on asbestos cement pipe. Installation of fire line services to AC pipe mains shall accomplished according to paragraph 3.B.16.

Joint Assembly:

- 2.7.23.10.1. Rubber Ring Joints: The installation of pipe and the assembly of rubber ring joints for Ductile-Iron pipe shall conform to the pipe manufacturer's assembly instructions. The method of inserting spigot ends of pipe in bells or collars known as "stabbing" shall not be permitted. Spigot ends of pipe must be properly inserted in the joint by means of suitable pushing/pulling devices or a manufacture approved method.

- 2.7.23.10.2. Mechanical Couplings: Mechanical couplings shall be assembled and installed according to the standards recommended by the manufacturer.

Mechanical coupling consists of a cylindrical steel middle ring, two steel follower rings, two rubber compound gaskets, and a set of steel bolts. The middle ring is flared at each end to receive the wedge-shaped gasket which is compressed between the middle ring flare and the outer surface of the pipe by pressure exerted on the follower rings through the bolt circle.

Prior to the installation of the mechanical coupling, the pipe ends shall be cleaned by wire brush or other acceptable method to provide a smooth bearing surface for the rubber compression gasket. The pipe shall be marked to align the end of the coupling which will center it over the joint. After positioning, the nuts shall be drawn up finger tight. Uniform pressure on the gaskets shall be applied by tightening alternate bolts on the opposite side of the circle in incremental amounts. Soap and final tensioning shall be accomplished with a torque wrench and in a matter similar to the tightening procedure after 15 minutes.

- 2.7.23.10.3. Restrained Joints: Restrained Joints shall be installed as shown on the plans or as directed by the Inspector. Installation shall conform to the manufacture's recommendations.

3.8 **Installation of the Nonmetallic Pipe Detection System.**

The nonmetallic pipe detection system is to be installed concurrently with the proposed pipe placement. Tracer wire shall be utilized for location purposes and taped directly to the pipe. The tracer wire shall be solid core (14 gauge insulated), and shall be tapered to the main in 10-inch increments. Wire shall also come up to the top of valve extensions and fire hydrant stems, as directed by the Engineer.

4. **MEASUREMENT**

This Item will be measured as follows: "Pipe Water Main (DI)", "Pipe Water Main (PVC)", "Pipe Water Main (PVC Casing) (Open Cut)", and "Pipe Water Main (Steel Casing) (Open Cut)" for water pipe of the various sizes shown on the plans, will be measured by the linear foot as follows: From the centerline intersection of runs and branches of tees to the end of the valve of a dead-end run.

Between the centerline intersections of runs and branches of tees, and where the branch is plugged for future connection, the measurement will include the entire laying length of the branch or branches of the fitting.

The measurement of each line of pipe of each size will be continuous and is to include the full laying lengths of all fittings and valves installed between the ends of such line except that the laying lengths of reducers will be divided equally between the connected pipe sizes. Lines leading to a tapping connection with an existing main will be measured to the center of the main tapped.

"Fire Lines" will be measured by the linear foot for each size and type from the centerline intersection of the fire line with the main distribution line to the property line. The measurement will include the entire laying length of the branch or branches of the fitting and valves. Line leading to a tapping connection with an existing main will be measured to the center of the main tapped.

"Jacking or Boring (Water Main)" will be measured by the linear foot of bore or tunnel as measured from face to face of jacking pits.

Carrier pipe used in bores and tunnels or backed into place will be measured by the linear foot of pipe installed from end to end of pipe to the limits shown on the plans

Casing or liners used in bores and tunnels, where required by the plans, of the size and material required will be measured by the linear foot actually installed in accordance with plans.

"Butterfly Valve and Box (Complete)" will be measured as each assembly of the various sizes installed.

"Gate Valve and Box (Complete)" will be measured as each assembly of the various sizes installed to finished grade.

"Cut-in Gate Valve and Box (Complete)" will be measured as each assembly of the various sizes installed to finished grade.

"Tapping Sleeve, Valve and Box (Complete)" will be measured as each assembly of the various sizes installed.

"Cut-in Tee (Complete)" will be measured as each assembly of the various sizes of cast-iron tees cut-in to the existing water main.

"Adjust Existing Valve Box" will be measured as each assembly adjusted to correspond to finish grade.

"Concrete Encasement, Concrete Cradles, Concrete Saddles and Concrete Collars" for pipe will be measured by the cubic yard as dimensioned on the plans, 6' in depth measured from the outside pipe diameter (0.0) or as directed. Reinforcing if required will not be measured for payment.

"Fire Hydrant with 6-in. Valve and Box" will be measured as each fire hydrant installed. Also included will be sufficient pipe, valve and fittings.

"Relocate Fire Hydrant" will be measured as each fire hydrant relocated.

"Permanent Blow-off (Complete)" will be measured as each assembly of the various sizes installed.

"Temporary Blow-off (Complete)" will be measured as each assembly of the various sizes installed.

"Automatic Air Release Valve (Complete)" will be measured as each assembly of the size installed.

"Trench Excavation Protection" and "Joint Trench Excavation Protection" will be measured by the linear foot along the centerline of trench where the depth of trench exceeds 5-ft.

"Tie-In (Complete)" will be measured as each of the various sizes and types completed.

"New Short Service" will be measured as each of the various sizes and types of new service lines installed.

"New Long Service" will be measured as each of the various sizes and types of new service lines installed.

"New Unmetered Short Service" will be measured as each of the various sizes and types of new unmetered service lines installed.

"New Unmetered Long Service" will be measured as each of the various sizes and types of new unmetered service lines installed.

"Reconnect Short Service" will be measured as each of the various sizes of service lines reconnected.

"Reconnect Long Service" will be measured as each of the various sizes of service lines reconnected.

"Relay Short Service" will be measured as each of the various sizes of service lines re-laid.

"Relay Long Service" will be measured as each of the various sizes of service lines re-laid.

"Relocate Short Service" will be measured as each of the various sizes of service lines relocated.

"Relocate Long Service" will be measured as each of the various sizes of service lines relocated.

"Relocate Existing Meter and Existing Meter Box" will be measured as each assembly relocated and customer's service reconnected.

"Relocate Existing Meter and New Meter Box" will be measured as each assembly relocated and customer's service reconnected.

"Cut and Replace Concrete Sidewalk, Driveway, Etc." will be measured by the square yard of surface area of the concrete sidewalk cut and replaced, but not to exceed the minimum trench width specified in Section 3.A.2, "Width of Trench" or as shown on plans.

"Cut and Replace Concrete Sidewalk (Asphalt)" will be measured by the square yard of surface area of concrete sidewalk to be cut and replaced with temporary asphalt (4-inch depth, Type C) pavement, but not to exceed the minimum trench width specified in Section 3.A.2, "Width of Trench" or as shown on the plans.

"Cut and Replace Asphalt Pavement" will be measured by the square yard of surface area of the asphalt pavement cut and replaced, but not to exceed the minimum trench width specified in Section 3.A.2, "Width of Trench" or as shown on plans.

"Concrete Curb" will be measured by the linear foot of the concrete curb cut and replaced, but not to exceed the minimum trench width specified in Section 3.A.2, "Width of Trench" or as shown on plans.

"Cut and Replace Asphalt Pavement with 6-in. Asphalt Treated Base" will be measured by the square yard of surface area of the asphalt pavement cut and replaced with 6-in. of asphalt treated base, but not to exceed the minimum trench width specified in Section 3.A.2, "Width of Trench" or as shown on plans.

"Hydrostatic Pressure Test" will be measured as each successful test conducted.

"Excavation" will not be measured for payment, but is to be considered subsidiary to the pipe installation.

"Flowable Backfill" will be measured by the cubic yard in accordance with Item 401, "Flowable Backfill", but not to exceed the minimum trench width specified in Section 3.A.2, "Width of Trench" or as shown on the plans.

"Installation of the Nonmetallic Pipe Detection System" will not be measured for payment, but is to be considered subsidiary to the pipe installation.

"Removing and Replacing Chain-Link and/or Wire Fence" will be measured by the linear foot of fence removed and replaced, regardless of the type or height of the fence, complete in place.

"Ductile Iron and Gray Iron Fittings" will be considered incidental to the pipe installation and a "No-Pay" item.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit prices bid for the items of work hereinafter described. These prices are to be full compensation for furnishing and hauling all materials; for placing or installing the materials; for inspection and testing; and for all other items of material, labor, equipment, tools and incidentals necessary to complete the work in accordance with the plans and specifications.

Payment for "Pipe Water Main (DI)", "Pipe Water Main (PVC)", "Pipe Water Main (PVC Casing)(Open Cut)", and "Pipe Water Main (Steel Casing)(Open Cut)" will be made at the unit price bid per foot of pipe of the various sizes installed by the open cut method. This payment is also to include selected bedding, excavation, backfill materials, polyethylene sleeve, all required fittings associated with the installation of the water main pipe of the various sizes, and hauling and disposition of surplus excavated materials.

Payment for "Fire Lines" installed will be made at the unit price bid for pipe of various sizes installed. Such payment shall include excavation selected embedment material, backfill, compaction of trench backfill, testing of compaction, tie-in, polyethylene sleeve where required, hauling, disposing of surplus excavated material, and restoration of surface. All replacement mains shall include tie-in costs for existing fire lines.

Payment for "Jacking or Boring (Water Main)", Jacking, Boring or Tunneling will be paid for at the contract unit price bid per linear foot of jacking, boring or tunneling, which price shall be full compensation for furnishing all materials (except carrier pipe, casings or liners), labor, tools, equipment and incidentals necessary to complete the work, including excavation, grouting, backfilling, restoration to original ground conditions, and disposal of surplus materials.

Carrier pipe used in bores or tunnels shall be paid for at the contract unit price bid for "Carrier Pipe for Jacking, Boring or Tunneling" per linear foot of pipe installed and measured as prescribed above.

Casings or liners used in bores or tunnels shall be paid for at the contract unit price bid for "Casing or Liner for Jacking, Boring or Tunneling" per linear foot of casing or liner installed and measured as prescribed above.

Payment for "Gate Valve and Box (Complete)" and "Tapping Sleeve, Valve and Box (Complete)" will be made at the unit price bid for each such assembly of the various sizes installed. This payment is also to include selected embedment material, anti-corrosion embedment when specified, concrete collar at the valve box where subjected to vehicular traffic, ductile iron riser pipe, cast-iron boot, packing, tarpaper, concrete grout, concrete reaction blocking, asphaltic material for bolts, nuts and ferrous surfaces, polyethylene sleeve, hauling and disposition of excavated surplus material and backfill where required. For butterfly valves only, such payment is also to include mechanical or transition couplings, and coated and wrapped steel pipe nipples required to complete the connection.

Payment for "Cut-in Gate Valve and Box (Complete)" will be made at the unit price bid for each such assembly of the various sizes installed. This payment is to include backfill, installation of valve, valve box assembly, all pipe cut and used to complete cut-in, reaction blocking, and polyethylene sleeve where required.

Payment for "Cut-in Tee (Complete)" will be made at the unit price bid for each of the various sizes of cast iron tees cut-in to ductile and cast iron mains. This payment is also to include necessary tie-ins, protective coating for bolts, nuts, ferrous surfaces, selected embedment material, anti-corrosion embedment when specified, backfill, pipe, fittings, polyethylene sleeve when required, concrete reaction blocking, and site restoration.

Payment for "Adjust Existing Valve Box" will be made at the unit price bid for each valve box adjusted to finish grade.

Payment will be made at the unit price bid for "Concrete Encasement, Concrete Cradles, Concrete Saddles and Concrete Collars" by the cubic yard of concrete placed. Reinforcing, if required, shall not be measured for payment.

Payment for "Fire Hydrant with 6-in Valve and Box" and "Relocate Fire Hydrant" will be made at the unit prices bid for each such assemblies installed.

These payments are to include backfill, selected material, anti-corrosion embedment when specified, branch line pipe, fittings exclusive of the tee from the main line pipe, polyethylene sleeve, hauling and disposition of excavated surplus material where required, asphaltic material for ferrous surfaces, concrete reaction blocking, concrete pad restoration of existing fire hydrant sites and installing a new fire hydrant as directed.

Payment for "Permanent Blow-off (Complete)" and "Temporary Blow-off (Complete)" will be made at the unit price bid for each such assembly installed in accordance with the details shown on the plans. Payment for the eccentric reducer will be made at the unit price bid for each ton of fittings of all types and sizes installed. Payment for the pipe nipple with reaction stop ring will be made at the unit price bid for each linear foot of pipe of the various sizes installed by the open cut method. These payments are also to include excavation, anti-corrosion when specified, the housing and disposition surplus excavated materials and approved selected backfill.

Payment for "Automatic Air Release Valve (Complete)" will be made at the unit price bid for each assembly of the various sizes installed in accordance with the details shown on the plans. This payment is also to include selected embedment material, anti-corrosion embedment when specified, excavation and hauling and disposition of surplus excavated materials, blocking and various sizes and types of meter boxes.

Payment for "Trench Excavation Protection" and "Joint Trench Excavation Protection" is to be made on the basis of the unit price bid for each linear foot of "Trench Excavation Protection" and "Joint Trench Excavation Protection" in place. Payment is to include all components of the trench protection system which can include, but not limited to sloping, sheeting, trench boxes or trench shields, sheet piling, cribbing, bracing, shoring, dewatering or diversion of water to provide adequate drainage. Payment is also to include the additional

excavation and backfill required, any jacking, jack removal and removal of the trench support after completion and be full compensation for all other labor, materials, tools, equipment and incidentals necessary to complete the work.

Payment for "Tie-In (Complete)" will be made at the unit price bid for each tie-in of the various sizes and types completed. This payment is to include shutdown and isolation of the existing main to which the tie is to be made, cutting pipe for connection, de-watering the excavation, and customer notification of service interruption where required. Connections between new and existing mains which are made with tapping sleeves and valves by cutting-in tees will be as a no-separate pay item.

Payment for "New Short Service" and "New Long Service" will be made at the unit price bid for each new service line of the various sizes and types installed. This payment is to include reconnection of new service to the existing meter and the adjustment of the meter, meter box, and Customer valve. Such payment shall also include excavation, trench excavation protection, hauling and disposition of surplus excavated materials, sand backfill, cutting pavement and surface structures of whatever type fittings of the various sizes used in the service line relay and copper tubing or ductile iron pipe (4-in. and larger).

Payment for "New Unmetered Short Service" and "New Unmetered Long Service" will be made at the unit price bid for each new un-metered service line of the various sizes and types installed. This payment is to include excavated materials, trench excavation protection, sand backfill, cutting in pavement and surface structures of whatever type encountered and replacement with whatever type specified, a new meter box where required, copper tubing or ductile iron pipe (4-in. and larger), valve and valve box assembly, and fittings of the various sizes used in the installation of new service lines.

Payment for "Reconnect Short Service" and "Reconnect Long Service" will be made at the unit price bid for each service line of the various sizes and types reconnected. This payment is to include excavation, trench excavation protection, hauling and disposition of surplus excavated materials, sand backfill, meter box relocation where required, cutting pavement and surface structures of whatever type encountered and replacement with whatever type specified, copper tubing or ductile iron pipe (4-in. and larger), valve and valve box assembly, and fittings of the various sizes used in the service line reconnection.

Payment for "Relay Short Service" and "Relay Long Service" will be made at the unit price bid for each service line of the various sizes and types relaid. This payment is to include reconnection of new service to existing meter, sand backfill, meter box relocation where required, copper tubing or ductile iron pipe (4-in. and larger), valve and valve box assembly, and fittings of the various sizes used in the service line relay.

Payment for "Relocate Short Service" and "Relocate Long Service" will be made at the unit price bid for each service line of the various sizes relocated. This payment is to include sand backfill, meter box relocation where required, copper tubing or ductile iron pipe (4-in. and larger) when required, valve and valve box assembly when required, and fittings of the various sizes used in the service line relocation.

Payment for "Relocate Existing Meter and Existing Meter Box" will be made at the unit price bid for each assembly relocated. This payment is also to include excavation protection, hauling and disposition of surplus excavated materials, sand backfill, removal and replacement of yard piping with piping of the various sizes and types and in the quantities necessary to complete the connection between the relocated existing meter and existing meter box, and the existing yard piping.

Payment for "Relocate Existing Meter and New Meter Box" will be made at the unit price bid for each assembly relocated. This payment is also to include sand backfill, removal and replacement of yard piping with piping of the various sizes and types and in the quantities necessary to complete the connection between the relocated existing meter and new meter box, and the existing yard piping.

Payment for the number one meter box installation in sidewalks and driveways shall be paid in the amount difference between the standard meter box and the number one meter box.

Payment for "Cut and Replace Concrete Sidewalk, Driveway, Etc." will be made at the unit price bid.

Payment for "Cut and Replace Asphalt Pavement" will be made at the unit price bid Payment for "Cut and Replace Asphalt Pavement with 6-in. of Asphalt Treated Base" will be made at the unit price bid.

Payment for "Cut and Replace Concrete Sidewalk (Asphalt)" will be made at the unit price bid.

Payment for "Concrete Curb" will be made at the unit price bid.

Payment for "Hydrostatic Pressure Test" will be made at the unit price bid for each successful test. Such payment includes all materials and equipment required to conduct test.

Payment for "Flowable Backfill" will be made at the unit price bid for each cubic yard of flowable backfill placed, but not to exceed the minimum trench width specified in Section 3.A.2. "Width of Trench".

Payment for "Removing and Replacing Chain-Link and/or Wire Fence" will be by the unit price bid per linear foot of fence removed and replaced.

No direct payment will be made for concrete blocking of water mains; coating and wrapping pipe joints; trench excavation below specified limits; excavation and removal of unsuitable material at bottom of trench grade and restoration with approved material; supporting pipe or conduits of public utilities; abandonment of water mains and valves; resetting existing meters and meter boxes in proper configuration; salvaging fire hydrants, valve boxes and meter boxes; flushing water mains; and disinfection of water mains. This work is to be considered subsidiary to the various bid items.

No direct payment will be made for furnishing and installing the nonmetallic pipe detection system. This work and materials are to be considered subsidiary to the various pay items. In addition, the Contractor is to ensure that the detection system is complete and operational to the satisfaction of the Engineer.

No direct payment will be made for furnishing and installing the pipe joint restraint system. This work and materials shall be considered subsidiary to the various bid items.

No direct payment will be made for furnishing and installing ductile and gray iron fittings. This work and materials shall be considered subsidiary to the various pay items

No direct payment will be made for furnishing and installing the Joint Restraint System for PVC C-905. This work and materials shall be considered subsidiary to the various pay items.

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the various unit prices. These prices are full compensation for furnishing materials and for equipment, labor, tools, and incidentals.

Special Specification 7049

Water Mains



1. DESCRIPTION

Furnish labor, materials, and equipment necessary to provide a complete water main system in conformance with the plans and specifications, and in compliance with the Department's Utility Accommodations Policy (Title 43, T.A.C., Sections 21.31-21.55). Construct water mains of the sizes, materials, and dimensions shown on the plans including pipe, joints, and connections to new and existing pipes, casing, valves, fittings, fire hydrants, meters, blocking, etc., as many as may be required to complete the work.

Furnish material and equipment for encasing existing water lines with split steel encasement pipes using the open cut method in accordance with this specification.

The abbreviations AWWA, ASA, ASTM, ANSI, AASHTO, NACE, NSF, SSPC, and TCEQ used in this specification refer to the following organizations or technical societies:

- AWWA American Water Works Association
- ASA American Standards Association
- ASTM American Society for Testing and Materials
- ANSI American National Standards Institute
- AASHTO American Association of State Highway and Transportation Officials
- NACE National Association of Corrosion Engineers
- NSF National Sanitation Foundations
- SSPC Steel Structural Painting Council
- TCEQ Texas Commission on Environmental Quality

References to specifications of the above organizations mean the latest standard or tentative standard in effect on the date of the proposal.

2. MATERIALS

All materials must conform to the requirements of this Item, the plans and the following Items:

- Item 421, "Hydraulic Cement Concrete"
- Item 440, "Reinforcement for Concrete"
- Item 441, "Steel Structures"
- Item 465, "Junction Boxes, Manholes, and Inlets"
- Item 471, "Frames, Grates, Rings, and Covers"

2.1. **General.** Provide new and unused materials for this project unless otherwise stated in the plans or proposal.

Pipe 6 in. or larger is acceptable to the Texas Fire Insurance Commission without penalty for use in water works distribution systems.

For water mains less than 24 in. in diameter, use casing insulators between the water main and casing unless otherwise shown on the plans. For water mains 4 in. through 14 in., use 8 in. wide casing insulators.

For water mains 16 in. through 20 in., use 12 in. wide insulators. For pipe materials up to 12 in., use Pipeline Seal and Insulator Model C8G-2 or approved equal. For water mains larger than 12 in. use Pipeline Seal and

Insulator Model C12G-2 or approved equal. Casing end seals: Pipeline Seal and Insulator Model C or approved equal.

2.2. **Steel Pipe and Fittings.**

- 2.2.1. **Steel Carrier Pipe.** Provide steel pipe for use as carrier pipe in the distribution system, conforming to the requirements of AWWA Standard C200. Install steel pipe 20 in. and smaller as aerial crossings, above-ground piping, and for encasement sleeves only. Do not bury steel pipe that is 20 in. and smaller directly or within a casing.

For pipe 24 in. and greater, conform to the requirements of AWWA C200, C207, C208 and AWWA M11 except as modified in this specification. Furnish pipe and fittings that have manufacturer's certifications ensuring that they have been hydrostatically tested at the factory in accordance with AWWA C200, Section 3.4. Ensure pipe steel meets the requirements of ASTM A36, ASTM A570 Grade 36, ASTM A53 Grade B, ASTM A135 Grade B, or ASTM A139 Grade B as a minimum. Pipe is also subject to the requirements of Underwriters Laboratories, Inc. Specification for "Steel Pipelines for Underground Water Service."

Provide pipe and fittings to withstand the most critical simultaneous application of external loads and internal pressures based on the minimum of AASHTO HS-20 loading, AREMA E-80 loads, depths of bury as indicated on the plans, and the most critical groundwater level condition. The pipe design conditions follow:

- Working pressure = 100 psi.
- Hydrostatic field test pressure = 150 psi.

For pipe design (24 in. and larger) conform to AWWA M11 with the following conditions:

- Design stress due to working pressure: The maximum is 50% of the minimum yield strength or 16,500 psi maximum stress for mortar-coated pipe.
- Design stress due to hydraulic test pressure: The maximum is 75% of the minimum yield strength or 24,750 psi maximum stress for mortar-coated pipe.
- Modulus of soil reaction (E'), <1,500 psi.
- Unit weight of fill (w) > 120 pcf.
- Deflection lag factor ($D1$) = 1.2.
- Bedding constant (K) = 0.1.
- Fully saturated soil conditions: $hw = h$ = depth of cover above top of pipe.
- Maximum deflection from specified diameter = 3% for flexible coatings.

Provide pipe and fittings that have been designed by a licensed Engineer. Before manufacturing, submit these signed, sealed, and dated calculations for approval.

Supply pipe in double random lengths unless otherwise shown on the plans. Bevel the ends of the pipe for field butt welding as shown on the plans.

Provide a minimum of 3/8 in. inside joint recess between ends of pipe in straight pipe sections.

Provide a minimum allowable steel wall thickness in accordance with Tables 1 and 2 for HS-20 live loads and depths of bury up to 16 ft.

Table 1
Carrier Pipe (20 in. and Smaller)

Nominal Pipe Size (in.)	Outside Diameter (in.)	Min Wall Thickness (in.)	Approximate Weight Per Lineal Ft., Uncoated (lb.)
4	4.500	0.250	11.35
6	6.625	0.280	18.97
8	8.625	0.322	28.55
10	10.750	0.365	40.48
12	12.750	0.375	49.56
16	16.000	0.375	62.58
20	20.000	0.375	78.60

Table 2
Carrier Pipe (24 in. and Larger)

Net Inside Diameter (in.)	Min Wall Thickness (in.)	
	Flexible Coating	Mortar Coating
24	0.149	0.136
30	0.149	0.136
36	0.178	0.163

Note: Refer to the plans for carrier pipe thickness. However, never use a pipe wall thickness less than that defined in the above tables.

2.2.2.

Steel Casing Pipe. Ensure pipe intended for use as casing pipe is manufactured in accordance with Section 2.2.1, "Steel Carrier Pipe," except to ensure that the minimum allowable steel wall thickness conforms to those shown in Table 3 for HS-20 live loads and depth of bury of up to 16 ft.

Table 3
Casing Pipe (Encasement Sleeves)

30 in. and Smaller			
Casing Pipe Size (in.)	Outside Diameter (in.)	Min Wall Thickness (in.)	Approximate Weight Per Lineal Ft., Uncoated (lb.)
8	8.625	0.219	19.64
10	10.750	0.219	24.60
12	12.750	0.219	29.28
16	16.000	0.219	36.86
18	18.000	0.250	47.39
20	20.000	0.250	52.73
24	24.000	0.250	63.41
30	30.000	0.250	79.43

Note: Refer to the plans for casing thickness. However, never use a pipe wall thickness less than that defined in the above table.

Provide steel casing sections for split casing in lengths a maximum of 20 ft. Ensure each section is split in half-sections. Bevel the ends and split sections for field butt-welding.

Steel casing pipe is not required to carry the label of the Underwriters Laboratories, Inc.

2.2.3.

Steel Pipe Fittings. Provide factory forged steel pipe fittings unless otherwise shown on the plans. Ensure the wall thickness is equal to or greater than the pipe to which the fitting is to be welded. Bevel the ends of the fitting for field butt-welding.

Provide approved sleeve-type flexible and flange adaptor couplings. Ensure the thickness of the middle ring is equal to or greater than the thickness of the pipe wall.

Provide restraint joint connections for 16 in. and larger water main piping shown on the plans to have restraint lengths, unless otherwise shown on the plans. Joints are to be double-welded at butt or lap joints at aerial crossings as shown on the plans. Use flanged joint at valves.

Elbows: Provide 2-piece for 0° to 22.5°; 3-piece for 23° to 45°; 4-piece for 46° to 67.5°; and 5-piece for 68° to 90°, unless otherwise shown on plans.

Outlets: Reinforced in accordance with AWWA M11, Sections 13.3-13.7, AWWA C200, and AWWA C208. Provide interior lining and exterior coating in accordance with paragraphs on coating and lining, and matching pipe to access inlets, service outlets, test inlets, and air-vacuum valve and other outlets, including riser pipes.

Radius: The minimum radius is 2.5 times pipe diameter.

- 2.2.4. **Hydrostatic Test of Pipe.** Ensure the pipe manufacturer performs hydrostatic testing in accordance with AWWA C200, Section 3.5.3, at the point of manufacture, conducts the test for a minimum of 2 min., and thoroughly inspects the pipe. Repair or reject pipe revealing leaks or cracks. Obtain from the manufacturer and submit to the Engineer, the manufacturer's written certification that the pipe and fittings used on this project have passed the hydrostatic test.

Calibrate pressure gauges within 1 yr. before testing, as specified in AWWA C200, Section 1.04 L.

- 2.2.5. **Butt Straps for Closure Piece.** Provide a minimum 12 in. wide split butt strap; minimum plate thickness equal to the thinnest member being joined; fabricated from material equal in chemical and physical properties to the thinnest member being joined.

Provide a minimum lap of 4 in. between the member being joined and the edge of the butt strap, welded on both the inside and outside, unless otherwise approved.

Provide a minimum 6 in. welded outlet for inspecting each closure section, unless the access man way is within 40 ft. of the closure section. Provide forged steel threaded outlets of approved design, where required, for use in passing hose or lead wires into the pipe. Tap plugs with standard pipe threads and weld to the pipe in an approved manner, and use solid forged steel plugs for closure.

Provide full penetration butt or welded joints as shown on the plans. Use flanged joints at valves unless otherwise shown on the plans. Perform x-ray or ultrasonic testing of manual welds on special pipe and fittings.

Dished Head Plugs: Provide dished head plugs (test plugs) to withstand field hydrostatic test pressure from either side of the plug. Ensure the design stress due to hydrostatic pressure is at most 50% of minimum yield. Pipe on the opposite side of the hydrostatic test may or may not contain water. Ensure the manufacturer of the steel pipe hydrostatically tests the plugs at the factory.

Make curves and bends by deflecting joints, by using beveled joints, or by combining these methods, unless otherwise shown on the plans. Do not exceed the joint deflection angle recommended by the pipe manufacturer.

Make penetration of spigot into bell at all points of circumference at least equal to minimum required penetration shown on the plans. Provide beveled pipe sections used in curved alignment of standard length except when shorter sections are required to limit the radius of curvature. In this case, provide equal length sections throughout the curve. Do not allow the bevel to exceed 5°.

- 2.2.6. **Steel Pipe Flanges.** Ensure steel pipe flanges shown on the plans conform to AWWA Standard C207 for Class D Flanges (same diameter and drilling as Class 125 cast-iron flanges ASA B16.1).

Make cast-iron to steel pipe connections with 1 cast-iron bell flange and 1 steel slip-on flange, and ensure they are electrically isolated.

The use of insulating gaskets, plastic bolt sleeves, and washers of insulating gasket material backed with zinc plated or hot-dip galvanized washers, or epoxy coated bolts, nuts, and washers used with an insulating gasket, are approved for this purpose.

For inline flange joints 12 in. in diameter and greater and for butterfly valve flanges, use Pyrex LineBacker Type E phenolic gaskets manufactured by Pipeline Seal and Insulator Inc., or approved equal.

Use full-face gaskets for other flanged joints not listed above. Provide cloth-inserted rubber gasket material, 1/8 in. thick in accordance with AWWA C207. Ensure gaskets are factory-cut to proper dimensions.

Maintain electrically isolated flanged joints between steel and cast-iron by using epoxy coated bolts, nuts, washers, and insulating type gaskets unless, otherwise approved.

Fabricate flanges with oversize bolt holes, with flanges drilled in pairs, to accommodate insulating sleeves.

2.2.7. **Steel Pipe Protective Coatings.**

- 2.2.7.1. **General.** Use shop-applied protective coatings except for field repairs and coatings of field welded joints. The Engineer may provide for witness of inspection and testing of shop-applied coatings, however, such witness does not relieve the Contractor of the responsibility to furnish material, perform work, and provide quality control in conformance with the applicable AWWA Standard and the requirements of these specifications.

The substrate surface profile and minimum and maximum individual and total dry film thickness (DFT) indicated in this specification apply. No requirement of this specification cancels or supersedes the specific written directions and recommendations of the specific coating manufacturer so as to jeopardize the integrity of the applied system. Measure the dry film thickness in accordance with SSPC PA2.

Field test shop coating and field repairs for holidays, pinholes, or discontinuities, at voltage levels required by the applicable AWWA Standard and in accordance with the applicable NACE procedure, i.e., PRO 188, RPO 274, TMD 384, etc. Submit the test procedure, including voltage levels to be used, before testing. Repair holidays in conformance with the applicable AWWA Standard.

Provide documentation by a NACE-certified inspector of compliance with the required tests.

Handle, store, and use field procedures for shop-coated pipe in conformance with the applicable AWWA Standards. Adequately seal and protect pipe ends from damage during handling and storage. Do not remove such protection until immediately before installing. Do not lift pipe using caliper clamps or hooks at ends of the pipe.

Repair damage to the pipe or the protective coating caused while installing the pipe and before final acceptance by the owner, as directed and in conformance with the applicable standards.

Keep the interior of the pipe and fittings clean of foreign matter before installing and until the work is accepted. Keep joint contact surfaces clean until jointing is complete.

Furnish an affidavit of compliance that all materials and work furnished comply with the requirements of the applicable AWWA Standard and these specifications.

- 2.2.7.2. **Internal Lining for Steel.** Ensure the material used for the internal coating of the steel carrier pipe is NSF61-listed as suitable for contact with potable water as required by Chapter 290, Rules & Regulations for Public Systems, Texas Commission on Environmental Quality (TCEQ).

Supply steel pipe with epoxy lining, capable of conveying water at temperatures not greater than 140°F. Provide linings conforming to American National Standards Institute/National Sanitation Foundation (ANSI/NFS) Standard 61, and certification from an organization accredited by ANSI. Unless otherwise noted,

coat exposed (wetted) steel parts of flanges, blind flanges, bolts, and access manhole covers, with epoxy lining as specified.

2.2.7.2.1.

Epoxy Lining. Use Liquid Epoxy meeting the requirements of AWWA C-210, "Liquid Epoxy Coating System for the Interior and Exterior of Steel Water Pipelines," except as modified in this specification. Provide a Liquid Epoxy system consisting of three coats of polyamide epoxy (no coal tar material) as follows:

- Prime Coat: 2-part, chemically cured, NSF certified epoxy, 4-6 mils dry film thickness (DFT).
- Intermediate Coat: 2-part NSF certified epoxy, 4-6 mils (DFT).
- Finish Coat: 2-part NSF certified epoxy, 4-6 mils (DFT).

Ensure the total system has a minimum DFT of 12 mils and a maximum DFT of 18 mils. Apply each coat in contrasting colors, using a buff prime and intermediate coat and a white finish coat. Use the same manufacturer to supply all material. Coal-tar epoxy material is not permitted. For surfaces to be coated, abrasive blast clean them to a near-white finish in accordance with SSPC-5(64) to establish an average anchor profile of 2.0 to 3.0 mils, with no individual reading greater than 4.0 mils or less than 1.5 mils. Before applying, inspect the prepared and cleaned surface for evidence of non-visible contaminants such as soluble salts or chlorides in accordance with NACE Technical Committee Report "Surface Preparation of Contaminated Steel Surfaces," NACE Publication 6G 186.

Re-clean the surface as necessary, until it is free of such contaminants.

Perform an interior adhesion test on pipe 30 in. in diameter and larger in accordance with ASTM D 4541.

Minimum field adhesion: 700 psi. Perform this test on pipe for project at a frequency of one for every 1000 sq. ft. of epoxy lining. Perform a cure test in accordance with ASTM D 4752 (solvent rub test) and ASTM D 3363 (pencil hardness) for each section of pipe. Repair tested areas with approved procedures.

Provide Fusion Bonded Epoxy in accordance with AWWA C-213, "Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines."

2.2.7.3.

External Coating.

2.2.7.3.1.

Above Ground. Externally coat above ground steel piping and fittings with a 3-coat epoxy/epoxy/polyurethane system in accordance with AWWA C-218, "Coating the Exterior of Aboveground Steel Water Pipelines and Fittings," Section 2.5, Coating System No. 4-91, except as modified in this specification.

- Prime Coat: 2-component, inhibitive epoxy primer; DFT of 4-6 mils.
- Intermediate Coat: 2-component, chemical resistant epoxy; DFT of 4-6 mils.
- Finish Coat: 2-component aliphatic polyurethane; DFT 1.5-2.5 mils.

Ensure the total system has a minimum DFT of 9.5 mils and a maximum DFT of 14.5 mils. Apply each coat in contrasting colors, using a buff prime coat and a blue finish coat, or as directed. Use the same manufacturer to supply all material. For surfaces to be coated, abrasive blast clean them to a near-white finish in accordance with SSPC-SP10 (NACE 2) to establish an average anchor profile of 2.0 to 3.0 mils, with no individual reading greater than 4.0 mils or less than 1.5 mils. Before coating, inspect the prepared and cleaned surface for evidence of non-visible contaminants such as soluble salts or chlorides in accordance with NACE Technical committee Report "Surface Preparation of Contaminated Steel Surfaces," NACE Publication 6G 186. Re-clean the surface as necessary, until it is free of such contaminants.

Perform an interior adhesion test on pipe 30 in. in diameter and larger in accordance with ASTM D 4541. Minimum field adhesion: 700 psi. Perform this test on pipe for the project at a frequency of one for every 1000 sq. ft. of epoxy lining. Perform a cure test in accordance with ASTM D 4752 (solvent rub test) and ASTM D 3363 (pencil hardness) for each section of pipe. Repair tested areas with approved procedures.

Provide Fusion Bonded Epoxy in accordance with AWWA C-213, "Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines."

2.2.7.3.2. **Buried Steel Pipe, 24 Inch Diameter and Larger Only.** Coat buried steel pipe and fittings (except tunneled, cased, or augered holes) with either of the following systems:

2.2.7.3.2.1. **Tape Coating.** Provide an approved tape for external tape coating. Apply in accordance with AWWA C214 and the requirements of this section; 80 mil shop-applied, Polyken YG-III, Tek-Rap Yard-Rap, or approved equal. Components: Primer, one 20 mil layer of inner-layer tape for corrosion protection and two 30 mil layers of outer-layer tape for mechanical protection. Bond coupling to adjacent pipes with bonding cables as shown on the plans.

Use approved filler putty, type Polyken 939 insulating putty, or approved equal, to fill in the gap and create a smooth sloped transition between the top of the reinforcing plate and the pipe, before applying the tape coating.

Primer: Compatible with the tape coating, supplied by the coating-system manufacturer.

Provide pipe with shop coatings cut back approximately 4 to 4-1/2 in. from the joint ends to facilitate joining and welding of pipe. Taper successive tape layers by 1 in. staggers to facilitate field wrapping and welding of joints. Inner and outer tape width: 12 in. or 18 in.

Do not expose tape coating to direct sunlight for more than 60 days.

Wrap specials and fittings that cannot be machine wrapped due to configuration, with primer layer and two layers of prefabricated tape, each 35 mils thick. Overlap machine applied tape with hand applied tape by minimum of 2 in. and bind to it.

Apply Polyken approved 30 mil filler tape 931, or approved equal, parallel to spiral weld seams if weld height measures greater than or equal to 1/8 in.

2.2.7.3.2.2. **Polyurethane Coating.** Refer to Section 2.2.7.3.1., "Above Ground." Heat Shrink Joint Sleeves for Tape Coating: Aqua-shield, or approved equal. For repairs to heat shrink joint sleeves, use Aqua-shield Repair Patch Kit, or approved equal.

2.2.7.3.3. **Steel Pipe in Tunneled, Cased, Bored, or Augered Holes.**

2.2.7.3.3.1. **24 Inch and Larger:** Prime steel pipe in tunneled or cased holes with 3.0 to 4.0 mils of a 2-part chemically cured rust inhibitive polyamide epoxy. Prepare the surface the same as for above ground external coating in accordance with Section 2.2.7.3.1., "Above Ground." Fill the annular space between the tunnel or casing with the specified grout.

2.2.7.3.3.2. **20 Inch and Smaller:** Coat steel pipe in bored or augered holes, or holes in a tunnel or casing, with Corropipe II-TX or Corroclad 2000 as manufactured by Madison Chemical Industries, Inc., or approved equal, and apply in strict conformance with the manufacturer's recommendations.

For external field welds and other field repairs, use Madison Chemical "GP" II or "TX" Touch Up, or approved equal, in conformance with the manufacturer's recommendations.

2.2.7.4. **Inspections and Testing of Coatings.** Perform electrical inspection on the inner layer of tape before applying the intermediate layer of tape. If holidays are detected, repair holidays immediately before applying the outer layer of tape. Clear the holiday area of material and re-prime if necessary. Re-coat the area with inner wrap tape. Overlap the inner wrap tape onto the surrounding inner wrap coating by at least 2 in. Perform an electrical re-test at the repaired area after repairing the holiday, and before continuing the outer wrap.

Shrink Wrap: Perform an electrical inspection on the shrink wrap to check for holidays. Perform peel tests over the heat affected zone. Minimum acceptable result: 15 lbs. ft. per inch.

2.3. **Ductile-Iron Pipe and Fittings.**

- 2.3.1. **Ductile-Iron Pipe.** Provide ductile-iron pipe conforming to the requirements of AWWA Standard C151. Provide minimum lengths of 18 ft. and minimum thickness of Class 51 for water lines. Provide minimum thickness Class 53 for flanged pipe and minimum thickness Class 52 for areas with pipe offset sections. Use joints of the push-on type or flanged type unless otherwise shown on the plans. Use push-on joints conforming to the requirements of ASA Specification A21.11 (AWWA C111). Use flanged joints conforming to the requirements of AWWA C115 including a cloth inserted rubber gasket material 1/8 in. thick for flanged joints. Do not use threaded or grooved type joints which reduce the pipe wall thickness below the minimum required.

Provide polyethylene encasement material and install in accordance with AWWA C105, and backfill as specified. Apply a minimum of two complete wraps of 8 mil thick polyethylene. Use polyethylene encasement for open cut installations only. For augered sections or sections installed inside a tunnel or casing, provide polyurethane coating.

Ensure the pipe manufacturer performs hydrostatic testing in accordance with AWWA C 151, Section 5.2.1, at the point of manufacture, conducts the test for a minimum of 2 min. and thoroughly inspects the pipe. Repair or reject pipe revealing leaks or cracks. Obtain from the manufacturer and submit to the Engineer, the manufacturer's written certification that the pipe and fittings used on this project have passed the hydrostatic test.

Prevent any lateral movement of thrust restraints throughout the pressure testing and operation. Passive resistance of soil will not be permitted in the calculation of thrust restraint.

Clearly mark the pipe section to show the location and thickness or pressure class color code.

Provide an exterior coating, in open cut excavations, consisting of a prime coat and an outside asphaltic coating conforming to AWWA C110, C115, or C151 for pipe and fittings. Encase the water line in a double wrap of polyethylene. Use polyethylene wrap conforming to the requirements of Section 2.13., "Polyethylene Film Wrap," and Section 3.16., "Polyethylene Film Wrap." Install bond wire as specified.

Coat Ductile-Iron pipe in augered holes with a polyurethane coating. Use a polyurethane coating conforming to the same requirements as those in Section 2.2.7.3.3., "Steel Pipe in Tunneled, Cased, Bored, or Augered Holes."

- 2.3.2. **Fittings for Ductile-Iron Pipe.** Ensure fittings for use with ductile-iron pipe of nominal sizes 4 in. through 48 in. conform to AWWA Standard C110 or C153.

Use joints of the push-on type or flanged type unless otherwise shown on the plans. Use push-on joints conforming to the requirements of ANSI Specification A21.11 (AWWA C111), rated for a 250 psig working pressure or A21.53 (AWWA C153). Use flanged fittings conforming to AWWA C110, of cast or ductile iron and conforming to ANSI B16.1, class 125 rated at 250 psig working pressure. Screw flanged fittings on threaded pipe ends done in the shop in accordance AWWA C115 for attaching, aligning, and facing.

Coat the inside and outside surfaces of the fittings as specified for the regular lengths of ductile-iron pipe.

Regardless of the coating system, for flanged joints in buried service, provide a petrolatum wrapping system, Denso, or approved equal, for the complete joint and alloy steel fasteners. Alternatively, provide bolts made of Type 304 stainless steel.

Bond joints in accordance with Section 2.6., "Joint Bonding and Electrical Insulation."

2.3.3. **Restrained Joints.** For buried services, restrain ductile iron pipe 16 in. diameter and larger from movement, using special joints. Provide the following or approved equal:

- Super-Lock Joint by Clow Corporation.
- Flex-Ring or Lok-Ring by American Cast Iron Pipe Company.
- TR-Flex or Field-Lok Joint by U.S. Pipe and Foundry Company.

Provide restrained joints with enough distance from each side of the bend, tee, plug, or other fitting to resist thrust developed at the design pressure for the pipe.

Use water main interior coatings conforming to AWWA C104 or ANSI A21.4, cement-lined with seal coat or ANSI A 21.16 fusion-bonded epoxy coating.

Ensure the material used for internal coating is NSF 61 and listed as suitable for contact with potable water as required by Chapter 290, Rules and Regulation for Public Water Systems, Texas Natural Resources Conservation Commission (TNRCC).

2.4. **Polyvinyl Chloride Pipe (PVC) Pipe and Fittings.**

2.4.1. **Polyvinyl Chloride Pipe, 2 Inch through 20 Inch.** Provide PVC pipe 4 in. and larger with integral bell type gasketed push-on joints or plain end pipe with twin-gasketed couplings conforming to the requirements of ASTM Designation D3139 for push-on-type joints. Use rubber gaskets conforming to the requirements of ASTM Designation D1869. Lubricate gaskets with a nontoxic water-soluble lubricant before joining pipe units. Fit pipe units together in such a manner to avoid twisting or damaging the rubber gasket.

Mark furnished PVC pipe on the spigot end for proper depth of makeup to the bell end of a joining length of pipe or fitting.

Provide valves for use with PVC pipe conforming to the requirements of Section 2.9., "Gate Valves, Tapping Valves, and Tapping Sleeves," except provide valve ends of the push-on-joint type for use with PVC pipe. Provide self-extinguishing PVC pipe that bears Underwriters' Laboratories mark of approval and is acceptable without penalty to Texas State Fire Insurance Committee for use in fire protection lines. Ensure PVC pipe bears the National Sanitation Foundation Seal of Approval (NSF-PW).

Provide PVC meeting the following thickness when using restrained joints:

- DR 18: For restrained joints where shown in the plans.
- DR 14: For alternate to offset pipe sections shown on the plans. Do not use PVC pipe for offset sections with depth cover greater than 20 ft. or less than 4 ft. Do not use PVC pipe in potentially petroleum-contaminated areas.

Make curves and bends by deflecting joints. Do not exceed the maximum deflection recommended by the pipe manufacturer. Submit details of other methods of providing curves and bends for review by the Engineer.

Gaskets: Use gaskets meeting the requirements of ASTM F 477. Use elastomeric factory-installed gaskets to make joints flexible and watertight. Flat Face Mating Flange: Full faces 1/8 in. thick ethylene propylene rubber (EPR). Raised Face Mating Flange: Flat ring 1/8 in. EPR, with filler gasket between the outside diameter (OD) of the raised face and the flange OD to protect the flange from the bolting moment. Lubricant for rubber-gasketed joints: Water-soluble, non-toxic, non-objectionable in taste and odor imparted to fluid, non-supporting of bacteria growth, and causing no deteriorating effect on PVC or rubber gaskets. Use one manufacturer to furnish PVC pipe. When an approved PVC system is used as alternate to offset pipe section, a second manufacturer may be used. Do not use PVC pipe in potentially or known contaminated areas. Do not use PVC pipe in areas exposed to direct sunlight.

Ensure the pipe manufacturer performs hydrostatic testing accordance with AWWA C 900, AWWA C 905, AWWA C 909, and ANSI A 21.10 (AWWA C 110) at the point of manufacture. Obtain from the manufacturer

and submit to the Engineer, the manufacturer's written certification that the pipe and fittings used on this project have passed the hydrostatic test.

- 2.4.2. **Fittings for Polyvinyl Chloride Pipe, 2 Inch.** Provide PVC pipe manufactured in accordance with the requirements of ASTM Designation D1784 for PVC 12454B (Type I, Grade 1) or PVC 12454C (Type I, Grade 1) and with a standard thermoplastic pipe dimension ratio (SDR) equal to 21.

Use fittings for 2 in. PVC pipe with a minimum pressure rating of 200 psi. Use fittings of the solvent-weld, socket type conforming to the requirements of ASTM D2466, or the gasketed push-on type conforming to the requirements of ASTM D2241. Use PVC solvent cements manufactured in accordance with ASTM D2564.

- 2.4.3. **Polyvinyl Chloride Pipe, 4 Inch Through 20 Inch.** PVC pipe 4 in. through 12 in.: AWWA C 900, AWWA C 909, Class 150, DR 18; AWWA C 900, Class 200, DR 14 as alternate to offset pipe sections; nominal 20 ft. lengths; cast-iron equivalent outside diameters. Pipe 14 in. through 20 in.: AWWA C 905; Class 235; DR 18; nominal 20 ft. lengths; cast-iron equivalent outside diameter.

Use joints conforming to the same requirements as those specified for 2 in. PVC pipe.

- 2.4.4. **Bends and Fittings for PVC Pipe, 4 Inch through 20 Inch.** Provide fittings conforming to the requirements of Section 2.3.2., "Fittings for Ductile-Iron Pipe." Use polyethylene wrapped fittings as required by Section 2.13., "Polyethylene Film Wrap," and Section 3.16., "Polyethylene Film Wrap."

Provide restrained joints with enough distance from each side of the bend, tee, plug, or other fitting to resist thrust developed at the design pressure for the pipe.

Approved Certa-Lok PVC restrained joints, 200-250 psi, may be provided for up to 12 in. in diameter. Where preventing movements of 12 in. diameter or greater pipe due to thrusts is necessary, provide the following restrained joints, or approved equal:

- 2.4.4.1. **Fittings.** JCM 610 Sur-Grip Fitting Restrainer by JCM Industries, Inc. or Series 500 Fitting Restrainer by Ebba Iron, Inc., One Bolt by One Bolt, Inc., or approved equal.

- 2.4.4.2. **Bell and Spigot.** JCM 620 or 621 Sur-Grip Bell Joint Restrainer by JCM Industries, Inc. or Series 1500 or Series 1100HV Joint Restrainer by Ebba Iron, Inc., One Bolt by One Bolt, Inc., or approved equal.

- 2.4.5. **Nonmetallic Pipe Detection.** Where nonmetallic pipe is installed longitudinally underground, provide for a method of detecting the location of the nonmetallic pipe. The specific method is shown on the plans or will be approved. This system may involve some components to be installed in the trench around the pipe to be detected using a metal detector. Or the system may consist of locating equipment capable of creating a non-destructive pressure wave which can be detected above ground using a portable detection device with both audible and visual indicators. Ensure either system of detection is capable of accurately locating the pipe to a maximum depth of 3 ft. over the areas shown on the plans.

Either system must be capable of locating lines under earth, concrete, or asphaltic surfaces. Use equipment, materials, and installation as specified by the manufacturer.

- 2.5. **Fiberglass Reinforced Plastic (FRP) Pipe for Casing.**

- 2.5.1. **FRP Casing Pipe.** Ensure pipe used for casing is centrifugally cast fiberglass pipe conforming to the requirements of AWWA Standard C 950 and the requirements of this section.

Design fiberglass casing pipe wall thickness to withstand the most critical simultaneous application of external loads, including construction loads and internal pressures. Base the design on the minimum of AASHTO HS-20 loading, AREMA E-80 loads, and depths of bury as indicated on the plans. Design for the most critical groundwater level condition. The pipe design conditions follow:

- Working Pressure = 100 psi

- Hydrostatic Field Test Pressure = 150 psi

Provide the pipe with pressure rated fiberglass sleeve couplings or O-ring bell-and-spigot joints that use elastomeric sealing gaskets to maintain joint water-tightness conforming to the requirements of ASTM D 4161. Provide the casing end treatments with rubber boot type seals capable of maintaining casing water-tightness. Provide casing pipe, gasketing and end treatments that have a very-low to zero corrosive reaction to the chemicals listed on the pipeline product lines shown in the plans. The pipeline products encountered at proposed water line crossings include, but are not limited to:

- MTBE (Methyl Tertiary Butyl Ether)
- TBA (tertiary butyl arsine)
- Nitrogen
- Benzene
- Petroleum
- Natural Gas
- Ethane

Provide pipe manufactured with an epoxy vinyl ester resin with the physical and chemical properties of HETRON 970-35 by Ashland, or approved equal.

Provide fiberglass casing sections in nominal lengths of 20 ft. Provide a stiffness class of fiberglass pipe that satisfies design requirements, but not less than 46 psi, when used in direct bury operation. For tunneled and augered sections, use pipe and pipe joints designed to carry loads including but not limited to: Overburden and lateral earth pressures, subsurface soil, grouting, other conditions of service, thrust of jacks, and stress anticipated during handling and installation. Do not create grout holes with pipe.

Submit shop drawings signed and sealed by a Professional Engineer licensed in State of Texas showing following:

- Manufacturer's pipe design calculations including thrust restraint design.
- Details of pictorial nature of critical features and specials indicating alignment and grade, laying dimensions, fabrication, fitting, flange, and fully dimensioned details, with plan view detailing pipe invert elevations, bends, and other critical features. Indicate station numbers for fittings corresponding to the plans. Do not start production of pipe and fittings before review and approval by Engineer. Provide final approved lay schedule on CD-ROM in Adobe Portable Document Format (*.PDF).
- Certification from manufacturer that design was performed for the project in accordance with the requirements of this section. This Certification is to be signed and sealed by Professional Engineer licensed in the State of Texas.
- Gasket and resin selection for approval.

- 2.6. **Joint Bonding and Electrical Insulation.** For electrical bond wires, use a minimum No. 2 AWG, 7 strand, and copper cable, furnished with high molecular weight polyethylene insulation (HMWPE). Remove 1 in. of HMWPE insulation from each end of the bond wire. Provide 2 bond wires as shown on the plans.

Provide a flange adaptor with an insulating kit, as required, when connecting new piping to existing piping and piping of different materials. Provide electrical flange insulation through the installation of the following materials:

- 2.6.1. **Insulating Gasket.**

- 2.6.1.1. **Piping Sized 30 Inches in Diameter and Greater.** Provide Pyrox G-10 with nitrile seal, Type E LineBacker gasket as manufactured by Pipeline Seal and Insulator, Inc. or approved equal.

- 2.6.1.2. **Piping Sized Between 12 Inches and 24 Inches in Diameter.** Provide Phenolic PSI with nitrile seal, Type E LineBacker gasket as manufactured by Pipeline Seal and Insulator, Inc., or approved equal.

The Contractor may provide a plain-faced phenolic gasket, as manufactured by Pipeline Seal and Insulator, Inc., or approved equal. Place the phenolic gasket between two full-faced gaskets. Provide cloth-inserted rubber gasket material, 1/8 in. thick in accordance with AWWA C207. Use gaskets that are factory cut to proper dimensions.

2.6.2. **Sleeves and Washers.**

2.6.2.1. **Piping Sized 30 Inches in Diameter and Greater.** Provide full length Mylar sleeves with Pyrox G-10 washers, double washer sets as manufactured by Pipeline Seal and Insulator Inc., or equal.

2.6.2.2. **Piping Sized Between 12 Inches and 24 Inches in Diameter.** Provide full length Mylar sleeves with phenolic washers, double washer sets as manufactured by Pipeline Seal and Insulator, Inc. or approved equal.

2.7. **Copper Tubing for Copper Service Lines and Small Mains.** For 3/4 in., 1 in., 1-1/2 in., and 2 in. diameter copper tubing for underground service, use Type "K" soft annealed and seamless with the proper bending temper and conforming to ASTM Designation B88 and Federal Specification WW-T-799 with the following exceptions:

Section 14 of ASTM Designation B88 is hereby modified to provide for the following number of samples for each size of tubing:

- For each 7,500 ft. of tubing 1 sample
- Items of less than 7,500 ft. of tubing 1 sample

Furnish 3/4 in. and 1 in. tubes in 60 ft. coils. Furnish 1-1/2 in. and 2 in. tubes in coils of minimum 40 ft. length. Use minimum joint spacing in multiples of 60 ft. or 40 ft. respectively

Provide flared or compression-type brass fittings for use with Type K annealed copper tubing in accordance with AWWA C800.

2.8. **Brass Fittings for Underground Services Lines and Small Mains (Less Than 24 inch Diameter).**

2.8.1. **General.** Unless otherwise provided in this specification, use brass fittings in underground installations of service lines and small mains in the water distribution system.

Use brass fittings composed of Copper Alloy No. C 83600 conforming to the requirements of ASTM Designation B62. Ensure the general pattern for each fitting conforms to that of standard brass fittings as manufactured by Mueller Company, Hays Manufacturing Company, or an approved equal.

Compression fittings may be used for unions except where they occur under existing or future paving. Use compression tube fittings with Buna-N beveled gaskets.

Ensure each fitting has the manufacturer's name or trademark and size plainly stamped into or cast on the body. Provide straight pipe adjacent to fittings for at least 10 in.

Provide waterways no smaller in diameter than the nominal size of the stop and accurately finish to a watertight joint; face all nuts and washers to a true fit; and design them such that the joint remains watertight and reasonably easy to operate after repeated use over a number of years. Use external threads conforming to AWWA Standard C800 and, on corporation stops, protect them in shipment by using plastic coatings or an alternate approved method.

2.8.2. **Corporation Stops.** Provide inlet ends of one of the following types: Standard corporation stop threads as specified in Table 1, AWWA C800; iron pipe thread (permissible for use with service saddles only); or Hays 4200- 4202 or approved equal.

Use one of the following types of valve body: Tapered plug type; O-ring seat ball type; or the rubber seat ball type.

Provide outlet ends with a flared-copper connection for use with Type-K soft copper or compression type fitting.

For PVC pipe, provide all brass corporation stops specifically designed for use with PVC pipe.

- 2.8.3. **Curb Stops.** Provide inlet ends with flared copper connections or compression type fittings.

Use a valve body with a straight through or angled meter stop design equipped with padlock wings and of the O-ring seal straight plug type or the rubber seat ball type.

Provide the outlet with female iron pipe threads or swivel nut meter spud threads, 3/4 in. and 1 in. stops, and with 2-hole flanges for 1-1/2 in. and 2 in. sizes.

- 2.8.4. **Service Saddles.** Provide service saddle with dual straps and one of the following types: Brass body and straps; ductile-iron body and straps, vinyl coated; ductile-iron body, vinyl coated with stainless steel straps.

Taps for PVC Water Mains: Use dual strap or single, wide band strap saddles which provide full support around the circumference of the pipe and a bearing area with enough width along the axis of the pipe, 2 in. minimum, to ensure that the pipe will not be distorted when the saddle is tightened. Use Romac Series 101N wide band, stainless-steel tapping saddle with AWWA standard thread (Mueller thread), or approved equal.

- 2.8.5. **Angle Stops.** Provide angle stops in accordance with AWWA C800; ground-key stop type with bronze locking head stop cap; inlet and outlet threads conforming to the application tables of AWWA C800; and inlet side with a flared connection or Mueller 110 compression type, or an approved equal.

- 2.8.5.1. **Outlet for 3/4 Inch and 1 Inch Size.** Provide meter swivel nut with saddle support.

- 2.8.5.2. **Outlet for 1-1/2 Inch through 2 Inch Size.** Provide O-ring sealed meter flange, iron pipe threads.

- 2.8.6. **Fittings.** Provide fittings in accordance with AWWA C800 and as described below:

- 2.8.6.1. **Castings.** Smooth, free from burrs, scales, blister, sand holes, and defects which would make them unfit for their intended use.

- 2.8.6.2. **Nuts.** Smooth cast and with symmetrical hexagonal wrench flats.

- 2.8.6.3. **Flare-joint Fittings.** Smooth cast. Machine seating surfaces for metal-to-metal seal, to proper taper or curve, free from any pits or protrusions.

- 2.8.6.4. **Thread Fittings.** Use N.P.T. threads and protect male threaded ends in shipment by using plastic coatings or other equally satisfactory means.

- 2.8.6.5. **Compression Tube Fittings.** Provide with a Buna-N beveled gasket.

Brass fittings will require the following testing:

- Submerge in water for 10 sec. at 85 psi with stops in both closed and open positions.
- Reject any fittings that show air leakage. The Department may confirm tests locally. An entire lot from which samples were taken will be rejected when random sampling discloses unsatisfactory fittings.

- 2.9. **Gate Valves, Tapping Valves, and Tapping Sleeves.**

- 2.9.1. **Gate Valves.** Use gate valves conforming to AWWA Standard C500, C509, C515, and the following supplemental specifications:

Provide direct-bury valves and valves in subsurface vaults that open clockwise. Provide above-ground valves that open counter-clockwise.

If the type of valve is not indicated on the plans, use gate valves as line valves for sizes less than 20 in. If the type of valve is specified, no substitute will be allowed.

Use a valve body of straight-through or angled, meter-stop design equipped with the following:

- O-Ring Seal – straight plug type.
- Rubber Seat – ball type

Provide the outlet end with female, iron-pipe threads or swivel-nut, meter-spud threads on 3/4 in. and 1 in. stops; and with a 2-hole flange on 1-1/2 in. and 2 in. sizes.

Where installing at depths greater than 4 ft., provide gate valves with a non-rising, extension stem with a coupling able to attach securely to the operating nut of the valve. Terminate the upper end of the extension stem in a square wrench nut no deeper than 4 ft. from the finished grade. Support the extension stem with an arm attached to the wall of the manhole or structure that loosely holds the extension stem and allows rotation in the axial direction only.

Provide gate valves in factory mutual type meter installations conforming to the provisions of this specification with outside screw and yoke valves, and carrying the label of Underwriter's Laboratories, Inc.

Provide coatings in accordance with AWWA C550; Indurall 3300 or approved equal, that are non-toxic; do not impart taste to water; function as a physical, chemical, and electrical barrier between base the metal and surroundings; and are a minimum 12 mil thick fusion-bonded epoxy. Before assembling the valve, apply the protective coating to the interior and exterior surfaces of the body.

Provide flange joints when the valve is connected to steel pipe.

Mount valves horizontally if the proper ground clearance cannot be achieved by a normal vertical installation. For horizontally mounted gate valves, provide bevel operation gear that is mounted vertically, for above ground operation.

- 2.9.1.1. **Gate Valves 1-1/2 Inches in Diameter and Smaller.** Use an operating pressure of 125 psi; bronze mounting; rising-stem; single-wedge; disc type; screwed ends; Crane No. 428, or approved equal.
- 2.9.1.2. **Gate Valves 2 Inches in Diameter.** Use an iron body; double gate; non-rising stem; 150 lb. test; 2 in. square nut operating clockwise to open.
- 2.9.1.3. **Gate Valves 4 Inches to 12 Inches in Diameter.** Non-directional; standard-wall resilient-seated in accordance with AWWA C509, parallel seat double disc in accordance with AWWA C500, or reduced-wall resilient-seated gate valves AWWA C515; operating pressure of 200 psi; pressure rating bronze mounting; push-on bell ends with rubber joint rings and nut-operated unless otherwise specified; resilient-seated provided by American Darling AFC-500, US Pipe Metro Seal 200, or approved equal; Reduced-wall resilient seated valves by American Flow Control Series 2500, or approved equal; double disc provided by American Darling 52, Clow F-6102, or approved equal; and comply with following unless otherwise shown on the plans:
 - 2.9.1.3.1. **Design.** Fully encapsulated rubber wedge or rubber seat ring mechanically attached with minimum 304 stainless steel fasteners or screws; threaded connection isolated from water by compressed rubber around opening.
 - 2.9.1.3.2. **Body.** Cast or ductile iron; flange bonnet and stuffing box together with ASTM A307 Grade B bolts. Cast the manufacturer's initials, pressure rating, and year manufactured into the valve body.

- 2.9.1.3.3. **Bronze.** Ensure that the valve components in the waterway contain at most 15% zinc and at most 2% aluminum.
- 2.9.1.3.4. **Stems.** ASTM B763 bronze, alloy number 995 minimum yield strength of 40,000 psi; minimum elongation in 2 in. of 12%; non-rising.
- 2.9.1.3.5. **O-rings.** For AWWA C509, Sections 2.2.6 and 4.8.2. For AWWA C500, Section 3.12.2. For AWWA C515, Section 4.2.2.5.
- 2.9.1.3.6. **Stem Seals.** Consist of 3 O-rings, 2 above and 1 below the thrust collar, with an anti-friction washer located above the thrust collar.
- 2.9.1.3.7. **Stem Nut.** Independent or integrally cast of ASTM B62 bronze.
- 2.9.1.3.8. **Resilient Wedge.** Molded; synthetic rubber; vulcanized and bonded to cast-iron or ductile-iron wedge tested to meet or exceed ASTM D429 Method B; or attached with 304 stainless steel screws; seat against epoxy-coated surface in the valve body.
- 2.9.1.3.9. **Bolts.** Furnish in accordance with AWWA C509 Section 2.2.5, AWWA C500 Section 3.4, or AWWA C515 Section 4.4.4 stainless steel; cadmium-plated, or zinc-coated.
- 2.9.1.4. **Gate Valves 14 Inches and Larger in Diameter.** AWWA C500; parallel seat double disc, or AWWA C515; reduced-wall, resilient-seated gate valves; flanged ends and nut-operated unless otherwise specified. Provide reduced-wall resilient-seated valves with 250 psig pressure rating and manufactured by American Flow Control Series 2500, or approved equal. Provide double disc valves with 150 psig pressure rating and manufactured by American Darling 52, Clow F-6102, or approved equal. Comply with following requirements unless otherwise shown on the plans.
- 2.9.1.4.1. **Body.** Cast iron or ductile iron; flange together bonnet and stuffing box with ASTM A 307 Grade B bolts. Cast the following into the valve body: manufacturer's initials, pressure rating, and year manufactured. When mounting horizontally, equip valves greater in diameter than 12 in. with rollers, tracks, and scrapers.
- 2.9.1.4.2. **O-rings.** For AWWA C500, Section 3.12.2. For AWWA C515, Section 4.2.2.5.
- 2.9.1.4.3. **Stems.** ASTM B 763 bronze, alloy number 995 minimum yield strength of 40,000 psi; minimum elongation in 2 in. of 12%, non-rising.
- 2.9.1.4.4. **Stem Nuts.** Machined from ASTM B 62 bronze rod with integral forged thrust collar machined to size; non-rising.
- 2.9.1.4.5. **Stem Seals.** Consist of 3 O-rings, 2 above and 1 below the thrust collar, with an anti-friction washer located above the thrust collar for operating torque.
- 2.9.1.4.6. **Bolts.** AWWA C500 Section 3.4 or AWWA C515 Section 4.4.4; stainless steel: cadmium-plated, or zinc-coated.
- 2.9.1.4.7. **Discs.** Cast iron with bronze disc rings securely pinned into machined dovetailed grooves.
- 2.9.1.4.8. **Wedging Device.** Solid bronze or cast-iron, bronze-mounted wedges. Thin plates or shapes integrally cast into cast-iron surfaces are acceptable. Provide other moving surfaces integral to wedging action that are bronze monel or nickel alloy-to-iron.
- 2.9.1.4.9. **Gear Cases.** Cast iron; furnished on 18 in. and larger valves and of extended type with steel side plates; lubricated; gear case enclosed with oil seal or O-rings at shaft openings.

- 2.9.1.4.10. **Bronze Mounting.** Built as integral unit mounted over, or supported on, cast-iron base and of sufficient dimensions to be structurally sound and adequate for imposed forces.
- 2.9.1.4.11. **Stuffing Boxes.** Located on the top of the bonnet and outside the gear case.
- Provide a bypass for double-disc gate valves 24 in. and larger.
- 2.9.1.5. **Gate Valves 14 Inches to 36 Inches in Diameter.** Provide AWWA C515, reduce-wall, resilient-seated gate valves with 250 psi pressure rating. Furnish with spur or bevel gearings.
- Mount valves horizontally if proper ground clearance cannot be achieved by normal vertical installation. For horizontally mounted gate valves, provide bevel operation gear mounted vertically for above ground operation.
- Use valve body, bonnet, wedge, and operator nut constructed of ductile-iron.
- Fully encapsulate the exterior of the ductile-iron wedge with rubber. Ensure the wedge is symmetrical and seals equally well with flow in either direction.
- Bolts: AWWA C515, Section 4.4.4, stainless steel; cadmium-plated or zinc-coated.
- Provide high-strength bronze stem and nut.
- O-rings: AWWA C515, Section 4.2.2.5, pressure O-rings as gaskets. Provide stem sealed by 3 O-rings. The top 2 O-rings are to be replaceable with the valve fully open at the full rated working pressure. Provide thrust washers for the thrust collar for easy valve operation.
- 2.9.2. **Tapping Valves.** Provide double disc or resilient wedge type tapping valves meeting the requirements of gate valves, as listed above, except for the type of joints; inlet flanges meeting AWWA C110, Class 125 or meeting AWWA C110, Class 150 or higher and with a minimum eight-hole flange. Provide outlets with standard mechanical or push-on type joints that fit any standard tapping machine.
- Provide a valve seat opening such that a full-size shell cutter for the nominal size tap may pass through the valve without any contact with the valve body.
- Provide valve boxes conforming to the requirements of Section 2.11., "Valve Boxes."
- 2.9.3. **Tapping Sleeves.** Provide tapping sleeve bodies in accordance with AWWA C110 ductile-iron; or AWWA C111 carbon steel; in 2 sections to be bolted together with high-strength, corrosion-resistant, low-alloy, steel bolts, and with mechanical joint ends.
- Provide flanged branch outlets of tapping sleeves; machined recess in accordance AWWA C207 Class D, ANSI 150 lb. drilling. Ensure the gasket is affixed around the recess of the tap opening to preclude rolling or binding during installation.
- Provide tapping sleeves with a 3/4 in. NPT test opening for testing before tapping. Provide a 3/4 in. bronze plug for the opening.
- 2.9.3.1. **Steel Sleeves.** Do not use steel sleeves for taps greater than 75% of the pipe diameter.
- Use steel sleeves only on pipe diameters 6 in. and larger. No "size-on-size" sleeve will be permitted (i.e., 6 in. x 6 in., etc.). To accomplish size-on-size connections, the next smaller tap may be made and a LEB (large end bell) increaser used. Where fire service from a 6 in. main is approved, only a ductile-iron split sleeve is permitted.

Provide a body of heavy welded steel construction. Groove the top half of the body to permanently retain a neoprene O-ring seal against the outside diameter of the pipe.

Provide fusion-bonded steel sleeves, epoxy-coated to a minimum 12 mil thickness. Ensure the finished epoxy coat is free of laminations and blisters; does not peel; remains pliant and resistant to impact. Ship steel sleeves in wooden crates that protect the epoxy coating during transport and storage.

Use bolts and nuts conforming to AWWA Standard C500, Section 3.5, and coated with a 100% vinyl resin (or made of corrosion resistant material).

Steel Tapping Sleeves: Use Smith Blair No. 622, Rockwell No. 623, JCM No. 412, or approved equal.

2.9.4. **Air Release and Vacuum Relief Valves.**

2.9.4.1. **Combination Air Valves.** Provide where combination air valves are designed to fulfill the functions of air release, permitting the air accumulated in the line at the high point of elevation to escape while the line is under pressure, and vacuum relief. Valve exterior: Paint with shop-applied primer suitable for contact with potable water. Provide Apco Model 145C or 147C, Val-matic Series 200, or approved equal valves as shown on the plans.

2.9.4.2. **Air Release Valves.** Provide with flanged inlet and outlet connections as specified on the plans. For 2 in. and 3 in. single body valves, size the orifice for a 100 psi working pressure. Fabricate the air relief valve of materials as follows: body and cover, ASTM A 48, Class 30 cast-iron; float and leverage mechanism, ASTM A 240 or A 276 stainless steel; orifice and seat, stainless steel against Buna-N or Viton mechanically retained with hex head nut and bolt. Other valve internals: stainless steel or bronze.

2.9.4.3. **Air Release and Vacuum Valves.** Provide single-body standard combination or duplex-body custom combination valves as shown on the plans.

2.9.4.3.1. **2 Inch and 3 Inch Single-body Valves.** Provide inlet and outlet sizes as shown on the plans and an orifice sized for a 100 psi working pressure. Valve materials: Body, cover, and baffle, ASTM A48, Class 35, or ASTM A126, Grade B cast iron; plug or poppet, ASTM A276 stainless steel; float, ASTM A240 stainless steel; seat, Buna-N; other valve internals, stainless steel. Paint valve exterior with an epoxy shop-applied primer. Provide Apco Model 145C or 147C, Val-Matic Series 200, or approved equal.

2.9.4.3.2. **3 Inch and Larger Duplex-body Valves.** As shown on the plans, provide an Apco Series 1700 with a No. 200 air release valve, GA Industries Fig. No. AR/GH-21K/280, or approved equal.

Air and vacuum valve materials: Body and cover, ASTM A48, Class 35, cast iron; float, ASTM A240 stainless steel; seat, Type-304, stainless steel and Buna-N; other valve internals, stainless steel or bronze. Air release valve: Construct as specified in Section 2.9.4.2., "Air Release Valves."

2.9.5. **External Coating Above Ground Valves.** Coat valves with a polyurethane coating conforming to the same requirements under Section 2.2.7.3.2.2, "Polyurethane Coating."

2.10. **Butterfly Valves.** Provide butterfly valves and operators conforming to the requirements of AWWA Standard C504 Class 150B, except as modified or supplemented in this specification. Provide short-body valves with a flanged design for closing against a flow velocity of 16 ft. per sec. at a normal working pressure of 150 psi and with a downstream pressure of 0 psi (Class 150B).

Provide direct-bury valves and valves in subsurface vaults that open clockwise. Provide above-ground and plant valves that open counter-clockwise.

Body: Cast iron, ASTM 126, Class B.

Discs for Butterfly Valves: Either cast-iron or ductile-iron.

Provide valves with Buna-N or neoprene seats mounted either on the disc or in the body. Mechanically secure the seats, not relying solely on adhesive properties of epoxy or similar bonding agents to attach the seats to the body. Mechanically retain the seats on the disc by using stainless steel (18-8) retaining rings held in place by stainless steel (18-8) cap screws that pass through a rubber seat for added retention. When the seat is on the disc, retain the seat in position by using shoulders located on both the disc and the stainless-steel retaining ring. Provide mating surfaces for seats of Type 304 or Type 316 stainless steel, secured to the disc by mechanical means. Sprayed on or plated mating surfaces will not be allowed. Provide a cast-iron disc conforming to ASTM A126, Class B or ductile-iron conforming to AWWA C151. The seat must be replaceable in the field for valves greater than 30 in. in diameter. Valves with segmented retaining rings will not be accepted.

Coat interior wetted ferrous surfaces of the valve, including the disc, with epoxy suitable for potable water conditions. Furnish epoxy, perform surface preparation, and apply epoxy in accordance with AWWA C550 and the coating manufacturer's recommendations. Provide 3 coats of 2-component, high-build epoxy with a minimum dry thickness of 12 mils. Use Indurall 3300, or approved equal, epoxy coating. Holiday test and measure the coatings for thickness.

Use Type 304 or Type 316 stainless steel for the valve shaft and keys, 24 in. in diameter and greater, that require a minimum of 2 in., or taper pins used for attaching the valve shaft to the valve disc. Do not use a torque plug to attach the valve shaft to the valve disc. All portions of shaft bearings: Stainless steel, bronze, nylon, or Teflon (supported by fiberglass mat or backing material with a proven record of preventing Teflon flow under load) in accordance with AWWA C504, stainless steel bearing material. Design the valve shaft to withstand 3 times amount of torque necessary to the open the valve.

Packing: Field-adjustable, split-V type, and replaceable without removing the operator assembly.

Retaining hardware for seats: Type 304 or Type 316 stainless steel. Nuts and screws used with clamps and discs for rubber seats: Securely held with lock tight, or other approved method, from loosening by vibration or cavitation effects.

Seat the valve disc in a position 90° to the pipe axis and ensure it rotates 90° between the fully-opened and tightly-closed position. Install valves with valve shafts horizontal and the convex side of the disc facing the anticipated direction of flow, except where shown otherwise on the plans.

Use push-on or flanged (flanged valves coupled to Bell-Flange adapters may be used) joint types for installation with cast-iron or ductile-iron pipe. Use flanges conforming in dimensions and drilling to ANSI B16.1 for cast-iron body valves, Class 125. Use bolts conforming to AWWA Standard C500, Section 9, in valve installations, including bolts for operators, housing, etc. Use flanged joints for steel or concrete steel cylinder pipes.

Provide properly sized gear type actuators for valves 8 in. and larger. Provide fully enclosed and traveling-nut type, rack and pinion type, or worm-gear type gear actuators. Equip direct-bury valves with a 2 in. square nut operating clockwise to open the valve. Completely enclose the space between the actuator housing and the valve body. Ensure that no moving parts are exposed to the soil or elements. Provide oil-tight and water-tight actuators, factory packed with suitable grease. Use operators conforming to the requirements of AWWA Standard C504 and equipped with adjustable limit stop devices.

Design worm-gear and traveling-nut operators so a torque of 150 ft.-lb. or less will operate the valve at the most adverse condition for which the valve is designed. Ensure the vertical axis of the operating nut does not move as the valve is opened or closed.

If the type of valve is not indicated on the plans, use butterfly valves for line valve sizes 24 in. and larger. For valves 24 in. and larger, provide valves manufactured by Pratt, Dezurik, or approved equal. Provide valves from an approved manufacturer. Provide valves and actuators from the same valve or actuator manufacturer. Ensure the shaft connecting the actuator to the valve body is fully enclosed. Provide a fully enclosed, watertight bonnet and extension

- 2.11. **Valve Boxes.** Provide Type "A," cast-iron or ductile-iron slide-type valve boxes as manufactured by Bass and Hays Foundry, Inc. or approved equal. Ensure the chemical composition of Casting "A" conforms to the requirements of AWWA Standard C110. Fabricate the base of each valve box from 6 in. cast-iron or ductile-iron pipe, conforming to the requirements of this specification except that the lining and coating will comply with this section.

Cast a letter "W" into the lid, 1/2 in. in height and raised 3/32 in., for valves serving potable water lines.

Coat boxes, bases, and lids by dipping them in hot bituminous varnish.

- 2.12. **Fire Hydrants.**

- 2.12.1. **General.** Provide fire hydrants, including 6 in. gate valve and box, conforming to the requirements of AWWA C502, except as modified or supplemented in this specification, and that are on the Utility Owner's approved products list.

Provide fire hydrants in conformance with AWWA C 502, Standards for Dry Barrel Fire Hydrants (Latest Edition). Provide hydrants that are approved by the City of Houston. Only hydrants with a current Certification of Responsibility will be allowed. The hydrants shown in Table 4 are currently approved. Alternative hydrants will not be considered.

Table 4
Approved Hydrants

Hydrant	City of Houston Engineering Control Drawing
U.S. Pipe and Foundry Con. M-94 Metropolitan 5-1/4 in. A495	DWG 960324 Rev. dated 2/06/02
Mueller Company Super Construction 250 5-1/4 in. A423	DWG FH-70 Rev. B dated 7/02/08
American AVK Company AVK Series 2780 Nostalgic	DWG 2780-Houston-2Rev. AAD3, dated 3/24/04

Ensure they are of dry-barrel, tamper resistant, and collision-safety construction design. Provide hydrants from same manufacturer throughout the project.

Installation of used, salvaged, or reconditioned fire hydrants will not be permitted.

- 2.12.2. **Hydrant Barrel.** Fabricate the lower hydrant barrel as a ductile-iron single piece, and connect it to the upper hydrant barrel by means of a joint coupling that will provide a 360° rotation of the upper barrel. Clearly mark the finish grade on the barrel. Provide the specified bury length, equal to the distance from the bottom of the inlet to the ground line.

Provide the hydrant barrel with a non-tapped, non-corrodible drain or drip valve, completely made of bronze or bronze-lined. Ensure the drain valve operates, automatically and positively, to drain the barrel when the hydrant valve is in the fully-closed position, and to completely close the drain opening so as to prevent leaking when the hydrant valve is in the open position.

Equip each hydrant barrel with two 2-1/2 in. nominal inside diameter hose nozzles and a single 4 in. nominal inside diameter pumper nozzle conforming with National (American) Standard Fire Hose Coupling Screw Threads, bronze (minimum Grade D) (per NFPA No. 194 and ANSI B26-1925).

Security fasten field-replaceable nozzles into the upper barrel by mechanical means, install by turning counterclockwise, seal with O-rings, and mechanically lock in place with a security device. Provide nozzles with nozzle caps and neoprene gasket seals. Securely attach the caps to the hydrant barrel with chains of not less than 1/8 in. diameter. Situate the pumper nozzle to allow an unobstructed radius of 10 in. from the threaded surface of the nozzle throughout the path of travel of a wrench or other device used to fasten a hose to the nozzle.

Orient the hydrant so that the pumper nozzle faces the curb or street nearest the hydrant.

Design the barrel joint connecting the upper and lower hydrant sections so that the hydrant shut-off valve will remain closed and reasonably tight against leakage in the event of an impact accident resulting in damage to or breaking of the hydrant above or near ground level. Provide the joint with a breakable bolt flange or breakable coupling including an adequate number of bolts, above finish grade.

Fabricate the operating and hold down nuts of stainless steel, cast-iron, or ductile-iron with bronze inserts. Provide a security device with each hydrant employing a bronze operating nut to protect this feature of the hydrant from malicious mischief or unauthorized removal. Ensure that such security devices do not require special tools for normal off/on operation of the hydrant. For the operating nut, use a tapered pentagon 1-1/2 in. point to face at the base, and 1-1/8 in. point to face at the top of the nut, opening left (counterclockwise). Fabricate hold down assemblies of metallic materials suitable for the intended service.

Design the hydrant barrel to permit the use of one or more standard extensions, available from the hydrant manufacturer, in lengths from 6 in. to 60 in. in 6 in. increments.

- 2.12.3. **Shut-off Valve and Inlet Shoe.** Provide hydrants with circular, compression-type shut-off valves which close with the water pressure, with center stem construction and which remain closed and tight against leakage upon impact. Ensure each shut-off valve is circular and not less than 5-1/4 in. in diameter. Seal the bottom end of the stem threads from contact with water by using a cap nut. Provide a bronze valve seat ring, threaded into a bronze drain ring to provide an all-bronze drain way. Ensure the seat ring and main valve assembly is removable from above ground through the upper barrel by using a light-weight seat removal wrench.

Construct the valve seat facing of molded rubber with a Durometer rating of 90 ± 5 , a minimum thickness of 1/2 in., and that is resistant to microbiological attack.

Unless otherwise shown on the plans, provide a hydrant inlet shoe that is an elbow with the AWWA standard bell designed for a nominal 6 in. mechanical joint hub end, or push-on assembly as specified. Provide a hydrant shoe of cast-iron or ductile-iron pipe that is flanged, swivel or slip joint with harnessing lugs for restrained joints. Coat the interior of the shoe with a minimum of 12 mils of fusion bonded epoxy conforming to NSF Standard 61. For underground flanging, incorporate a minimum of six 3/4 in. diameter electro-galvanized or cadmium-coated steel bolts or four 5/8 in. diameter stainless or cadmium-coated steel bolts.

- 2.12.4. **Valve Stem.** Where threads are located in the barrel or waterway, use Everdure operating stems, or other high-quality, non-correctible metal.

Use bronze-to-bronze working parts in the waterway; genuine wrought-iron or steel where threads are not located in the barrel or waterway, bronze bushed at the penetration of the stuffing box; seal the threads against contact with water regardless of the (open or closed) position of the main valve. Provide the valve stem with a breakable stem coupling opposite the barrel breakaway feature. Construct connecting pins and locking devices of bronze or other corrosion-resistant material. Provide the valve stem with a bronze sleeve, O-ring seals, and travel stop. Ensure the operating threads, working parts, and bearing surfaces are fully lubricated during normal operation of the fire hydrant. Ensure the lubricant is contained in a lubricating reservoir that is sealed at the top and bottom. Equip the operating assembly with a thrust bearing or lubricated thrust collar to minimize operating torque. Provide a lubricant meeting the requirements of FDA 21 CFR 178.3570 and manufactured with FDA-approved oxidation inhibitors.

Provide a valve stem that operates counterclockwise (turning to the left) to open.

- 2.12.5. **Gaskets and Seals.** Provide dynamic seals of O-ring type, oil-resistant material, which do not require adjustment for a watertight seal. Provide moving parts in contact with the seal made of bronze or other corrosion-resistant material.

Provide static seals of Buna "N" or other approved synthetic composition.

- 2.12.6. **Painting.** Shop coat the fire hydrant's exterior with 1 coat of rust prohibitive primer. Ensure the top half of the hydrant from the traffic flange up, receives 1 coat of blue enamel before delivery to the jobsite as outlined by the following:

- 2.12.6.1. **Exterior Above the Traffic Flange (Including Bolts and Nuts).** Prepare the surface in accordance with SSPC-SP10 (NACE 2), near-white blast-cleaned surface.

Coat with a 3-coat alkyd/silicone/alkyd system with a total dry film thickness (DFT) of 6-9 mils as follows:

- Prime Coat. Oil Modified Alkyd Primer, Acro Products No. 1104, Heavy Duty Tank & Steel Primer, or approved equal, in general accordance with SSPC Paint Specification No. 25. Apply with a total dry film thickness (DFT) of 2-3 mils.
- Intermediate Coat. Heavy Duty Heavy Duty Industrial Alkyd Enamel, Acro Products No. 2214, or approved equal, in general accordance with SSPC Paint Specification No. 104, and Federal Standard TT-E-489. Apply with a total dry film thickness (DFT) of 2-3 mils.
- Finish Coat. Silicone Alkyd Resin Enamel, Acro Products No. 2215, or approved equal, in general accordance with SSPC Paint Specification No. 21. Total dry film thickness (DFT) of 2-3 mils. Except do not finish shop coat the hydrant bonnet, only intermediate coat it. Field applies and color code the finish coating when installed.
- Colors. For primer, use the manufacturer's standard color. For the finish coat of the hydrant body, use blue (Acro 555 crystal blue or equivalent). Finish coat the hose connection caps white, and paint a white band of finish coat 2 in. in width on the hydrant body approximately 6 in. above and parallel to the traffic flange. For intermediate coat, use a contrasting color to the blue finish coat, such as white.

- 2.12.6.2. **Exterior Below the Traffic Flange.** Prepare the surface in accordance with SSPC-SP10 (NACE 2), near-white blast-cleaned surface.

Coat with a 3-coat system as follows:

- Primer and intermediate coat - coal tar epoxy, Acro Products No. 4467, or approved equal, in general accordance with SSPC Paint Specification No. 16. Apply 2 coats with a dry film thickness (DFT) of 8-10 mils each, for a total dry film thickness (DFT) of 16-20 mils.
- Finish coat - water based vinyl acrylic mastic, Acro Products No. 7782, or approved equal. Apply 1 coat with a dry film thickness (DFT) of 6-8 mils. For the color of the finish coat, use the same as for the finish coat for the exterior above the traffic flange i.e., blue (Acro 555 crystal blue or equivalent).

- 2.12.6.3. **Interior Surfaces Above and Below the Main Valve.** Provide material used for internal coating of hydrant interior ferrous surfaces below the main valve that is NSF61 listed as suitable for contact with potable water, as required by Chapter 290, "Rules and Regulation for Public Water Systems," Texas Commission on Environmental Quality (TCEQ).

Prepare the surface in accordance with SSPC-SP10 (NACE 2), near-white blast-cleaned surface.

Provide a liquid or powder epoxy system coating in accordance with AWWA Standard C-550. Apply the coating in 2 or 3 coats, according to the manufacturer's recommendations, for a total dry film thickness of 12-18 mils.

- 2.12.6.4. **General.** Apply coatings in strict conformance with the manufacturer's recommendation. No requirement of this specification cancels or supersedes the written directions and recommendations of the specific coating manufacturer so as to jeopardize the integrity of the applied system.

Ensure the hydrant supplier furnishes an affidavit of compliance that the materials and work furnished comply with the requirements of this specification and referenced applicable standards.

After installing the hydrants and before the main is accepted, paint the bonnet portion of each fire hydrant as shown in Table 5.

Table 5
Fire Hydrant Bonnet Colors

Size of Supply Line (in.)	Color of Bonnet
6	Yellow
8	White
10-20	Green
24 and Larger	Orange

Ensure the color shades and paint quantities are approved and comply with the current specifications.

- 2.12.7. **Performance Standards.** Provide hydrants capable of a free discharge of 1,500 gal. per minute (gpm) or greater, from a single pumper nozzle at a hydrant inlet static pressure not exceeding 20 psig as measured at or corrected to the hydrant inlet at its centerline elevation.

Provide hydrants capable of a discharge of 1,500 gpm or greater from a single pumper nozzle at a maximum permissible head loss of 8.0 psig (when corrected for inlet and outlet velocity head) for an inlet operating pressure not exceeding 37 psig as measured at or corrected to the hydrant inlet at its centerline elevation.

- 2.12.7.1. **Hydraulic Performance Testing.** AWWA C502; ensure the certified pressure loss and quantity of flow test is conducted by a qualified testing laboratory on a production model (5-ft. bury length) of the hydrant (same catalog number) proposed for certification. Submit a certified test report containing following information:

Date of test, within the previous 5 yr., on a fire hydrant with similar hydraulic characteristics.

Name, catalog number, place of manufacture, and date of production of hydrants tested.

Schematic drawing of testing apparatus, containing dimensions of piping elements including:

- Diameter and length of inlet piping.
- Distance from flow measuring points to pressure measurement point.
- Distance from flow and pressure monitoring points to the hydrant inlet.
- Distance from pressure monitoring point to nozzles.
- Diameter and length of discharge tubing.

Elevation of points of measurement, inlet, and outlet.

Reports or certificates documenting the accuracy of the measuring devices used in testing.

Conduct the tests on at least 3 hydrants of the same fabrication design. Inlet water temperature: 70°F ± 5°F.

For traffic impact testing, submit a certified test report outlining the results of the traffic impact test involving standard production models of the fire hydrant with breakable barrels of the same design as that proposed for certification. Install these hydrants per AWWA C600; strike at a point 18 in. ± 2 in. above the designated ground line. Conduct tests using the point of impact on hydrant barrel within 2 in. of a line perpendicular to base and equidistant from the pumper nozzle and one hose nozzle.

Conduct successive tests simulating impacts by standard American-made vehicles with gross weights of 3,500 lb., 5,500 lb., and 10,500 lb.

Document the tests to provide the following minimum information:

- Detailed schematic drawings of the test facility.
- Complete description of the mechanical impact testing equipment used.
- Complete list of the hydrant parts and materials damaged in each impact test.
- Photographs.

- Size and static pressure of the line to which the hydrant is attached.
- Estimated of amount of water discharged, if any, from the hydrant within 30 min. immediately following the collision.

2.12.8. **Hydrant Leads.** Provide hydrant branch leads conforming to the same requirements under Section 2.2.3., “Steel Pipe Fittings;” Section 2.3., “Ductile-Iron Pipe and Fittings;” or Section 2.4., “Polyvinyl Chloride Pipe (PVC) Pipe and Fittings.”

2.13. **Polyethylene Film Wrap.**

2.13.1. **General.** Except where noted on the plans, use polyethylene film as a wrap to protect cast-iron pipe, ductile-iron pipe, and fittings. Provide polyethylene film conforming to the requirements outlined in this specification and use only in open-cut construction.

2.13.2. **Film.** Provide polyethylene film in accordance with ASTM 1248 and AWWA C105, Type 1, Class C, Category 5, Grade J-3, 2.5% to 3% carbon black content. Unless otherwise shown on the plans, provide film 8 mils thick with a minimum tensile strength of 1,200 to 2,500 psi, elongation up to 600% and either in tubular or sheet form. Furnish film supplied in tubular form in the minimum widths shown in Table 6.

Table 6
Minimum Width of Film Tube (when laying flat)

Nominal Pipe Size (in.)	Push-on Joint Flat Tube Width (in.)
4	14
6	17
8	21
10	25
12	29
14	33
16	37
18	41
20	45
24	53

For film in sheet form, furnish in widths equal to twice that shown for tube widths.

2.13.3. **Polyethylene Tape.** For taping film edges and overlays, use 3 in. wide plastic-backed adhesive tape. Use Polyken No. 900, Scotch Wrap No. 50, or approved equal.

2.14. **Bedding Material.** Unless otherwise shown on the plans, provide one of the following types of bedding for water mains:

2.14.1. **Bank Run Sand.** Furnish bank run sand bedding as called for in these specifications and consisting of soil classified as SP, SW, or SM by the Unified Soil Classification System (USCS). Provide sand with a plasticity index, when tested, of less than 7% and a liquid limit of 25 or less. Ensure the bank run sand gradation has a maximum of 15% passing the No. 200 sieve when tested, and is free of roots, organic material, trash, clay lumps, or other deleterious or objectionable material.

2.14.2. **Concrete Sand.** Furnish concrete sand bedding conforming to the specifications for Fine Aggregates specified in ASTM Standard C-33. Provide Fine Aggregates consisting of natural sand, manufactured sand, or a combination of the two, within the gradation limits shown in Table 7.

Table 7
Fine Aggregate Gradation

Sieve Size	Percent Passing
3/8 in.	100
No. 4	95-100
No. 8	80-100
No. 16	50-85
No. 30	25-60
No. 50	10-30
No. 100	2-10

Ensure the aggregates do not contain any roots, organic material, trash, clay lumps, or other deleterious or other objectionable materials, in excess of the limits prescribed in the C-33 Standard.

- 2.14.3. **Pea Gravel.** Furnish pea gravel bedding conforming to the specifications for Coarse Aggregates specified for No. 8 size in ASTM Standard C-33. Provide Coarse Aggregates consisting of gravel composed of small, smooth, rounded, stones or pebbles, within the gradation limits shown in Table 8.

Table 8
Coarse Aggregate Gradation

Sieve Size	Percent Passing
1/2 in.	100
3/8 in.	85-100
No. 4	10-30
No. 8	0-10
No. 16	0-5

Ensure the aggregates do not contain any roots, organic material, trash, clay lumps or other deleterious or other objectionable materials, in excess of the limits prescribed in the C-33 Standard.

- 2.14.4. **Gem Sand.** Furnish gem sand generally conforming to specifications for Coarse Aggregates specified for No. 8 size in ASTM Standard C-33. Specifically, provide aggregates within the gradation limits shown in Table 9.

Table 9
Gem Sand Gradation

Sieve Size	Percent Passing
3/8 in.	95-100
1/4 in.	60-80
No. 4	15-40
No. 10	0-5

Ensure the aggregates do not contain any roots, organic material, trash, clay lumps, or other deleterious or other objectionable materials, in excess of the limits prescribed in the C-33 Standard.

- 2.15. **Backfill Material.** For sand backfill encasement of water mains, use one of the following materials, unless otherwise shown on the plans:

- 2.15.1. **Cement Stabilized Sand.** Furnish cement stabilized backfill containing a minimum of 5% cement per cu. yd. of material placed, based on the dry weight of the aggregate in accordance with Tex-120-E. Provide materials consisting of aggregate, cement, and water. Use cement and water conforming to the material requirements of Item 421. Provide sand aggregate, free from deleterious matter, with a plasticity index not greater than 6 when tested by Tex-106-E.

- 2.15.2. **Earth or Native Soil.** Furnish earth or native soil backfill consisting of soil containing no deleterious material such as trash, wood fragments, organic, or other objectionable material. Supply the material from either the material removed from the excavation or from offsite sources.

The material may consist of soil classified by the Unified Soil Classification System (USCS) as ML, CH, CL, CL-ML, SC, SP, SM, SW, or GC. Use earth backfill that meets the compaction requirements specified in this specification and does not cause any settlement.

- 2.15.3. **Bank Run Sand.** Furnish bank run sand backfill as called for in these specifications and conforming to the same requirements as those under Section 2.14.1., "Bank Run Sand."
- 2.16. **Concrete.** Use Class "A" concrete in conformance to the requirements of Item 421, unless otherwise shown on the plans. Leave the forms in place unless directed to remove certain sections of the forms.
- 2.17. **Water Meters, Meter Vaults, and Meter Boxes.**
- 2.17.1. **Water Meters.** Provide meters of the type and size indicated on the plans.
- 2.17.1.1. **Provide Bolted Split Casings.** Main casings of meters and external fasteners: Copper alloy with minimum 75% copper for 5/8 in. to 2 in., bronze or cast-iron, hot-dipped galvanized or epoxy coating for coating for 3 in. and larger.
- 2.17.1.2. **Straightening Vanes.** Use non-corrosive material compatible with the case material.
- 2.17.1.3. **Intermediate Gear Train.** Do not allow the intermediate gear train to come in contact with water; operate in suitable lubricant.
- Register: Automatic Meter Reading (AMR) type that provides pulse, contact closure, piezo switch, or encoder-generated output signal, compatible with Utility Owner's radio and telephone AMR systems. Provide a minimum 12 ft. of wire when permanently connected to the register. Lens: impact resistant. Register box: tamper resistant by means of a tamper screw or plug: Register: permanently sealed, straight-reading, center-sweep test hand, magnetic driven, reading in U.S. gal. Digits: 6, black in color with the lowest registering three digits (below 1,000 gal. registration) in contrasting digit and background colors. Register capacity of meters: 9.99 million gal. for 5/8 in. to 2 in. and 999.999 million gal. for 3 in. and larger.
- Connections: 5/8 in. to 1 in.: threads at each end; 1-1/2 in. to 2 in.: two-bolt oval flanges each end; 3 in. and larger: flange at each end.
- Stamp the manufacturer's meter serial number on the outer case. Stamp the manufacturer's meter serial number on the outside of the register lid, when provided. Ensure the manufacturer's serial numbers are individual and not duplicated.
- Meters: Equip with AMR type register to connect to the Utility Owner's AMR system. Compound Meter manufactured by: Badger, Hersey Products, Neptune, Sensus, or approved equal. Turbine Meters: manufactured by Badger, Hersey Products, Neptune, Sensus, or approved equal.
- Fire Service Meters: manufactured by Hersey Products, Neptune, Sensus, or approved equal. Displacement Meters: manufactured by Badger, Neptune, Hershey, Kent, Sensus, or approved equal.
- 2.17.1.4. **Manufacturing Quality Control.** Permit successful interchangeability from one meter to another of same size; registers, measuring chambers and units, discs or pistons as units, change gears, bolts, nuts, and washers, without affecting the accuracy of the new meters.
- 2.17.1.5. **Commercial Meter Valves for Meter Installations.** Provide commercial meter valves identical to line valves except provide them with Class 125 flanges and equip them with hand wheels operating counterclockwise to open.
- For pipe and fittings inside the meter box or meter vault, use ductile-iron conforming to Section 2.3., "Ductile-Iron Pipe and Fittings," and as specified on the plans.
- 2.17.2. **Meter Vaults.**
- 2.17.2.1. **General.** Furnish meter vaults in either of the following designs: precast concrete vault, cast-in-place concrete vault, or solid masonry, unless a specific type of construction is required on plans. Ensure

dimensions and reinforcement complies with the Utility Owner's standard meter vault drawings for the type and size shown on the plans. Use Class "S" concrete conforming to the requirements of Item 421.

- 2.17.2.2. **Precast Concrete Vaults.** Construct precast concrete vaults as shown on the plans. Use reinforcing steel conforming to the requirements of Item 440.

Install precast vaults in conformance with the manufacturer recommendations. Set level and on a minimum 3 in. thick bed of sand conforming to the requirements of Section 2.15, "Backfill Material." Seal lifting holes with cement mortar or non-shrink grout.

- 2.17.2.3. **Meter Vault Floor Slab.** Slope the floor 1/4 in. per foot toward the sump. Make the sump 12 in. in diameter, or 12 in. square, and 4 in. deep, unless other dimensions are shown on the plans. Install dowels at a maximum of 18 in., center-to-center, or install a mortar trench for keying the walls to the floor slab.

- 2.17.2.4. **Cast-In-Place Concrete Vaults.** Construct cast-in-place concrete vaults as shown on the plans. Use reinforcing steel conforming to the requirements of Item 440. Key the walls to the floor slab.

- 2.17.2.5. **Frame and Cover.** Use A-36 welded steel, or approved equal. Fabricate the cover plate with a 1/4 in. skid-resistant raised pattern floor plate. Fabricate the meter access door from the same material as the cover plate. Perform welding in accordance with the provisions of Item 441. Nondestructive testing will not be required.

Furnish castings for frames, grates, rings, and covers conforming to ASTM A48 Class 30. Provide locking covers if indicated on the plans. Use castings capable of withstanding the application of an AASHTO HS-20 loading, unless otherwise specified.

Provide covers and frames conforming to the shape dimensions, and with the wording or logos shown on the plans. The standard diameter dimension for manhole covers is 32 in. Furnish frames, grates, rings, and covers conforming to Item 471, except as noted above and except for measurement and payment.

- 2.17.3. **Meter Boxes.**

- 2.17.3.1. **General.** Furnish meter boxes for 5/8 in. through 1 in. meters of the following materials:

- Non-traffic bearing locations: cast-iron, concrete, or plastic as specified on the plans.
- Traffic bearing locations: cast iron.

Meter boxes for 1-1/2 in. and 2 in. meters: cast-iron. Provide meter box lids with a key-operated, spring type, locking device and a reading lid. Ensure the lids contain enough metals so that the meter box is easily located with metal a detector. If words are specified on the plans, cast them into lid with letters of 1/2 in. height and raised by 3/32 in. Ensure the size reads 5/8 in. to 1 in. or 1-1/2 in. to 2 in.

Furnish meter boxes conforming to the following approximate dimensions:

- Length: At the top, 15-1/2 in.; at the bottom, 20 in.
- Width: At the top, 12-1/2 in.; at the bottom, 14-3/4 in.
- Height: 12 in.

Ensure that meter box extensions 3 in. and 6 in. in height are available from the manufacturer.

- 2.17.3.2. **Cast-Iron Meter Boxes.** Furnish cast-iron boxes that are clean and free from sand blow-holes or other defects, and conforming to the requirements of ASTM A48. Machine the bearing surfaces so that the covers seat evenly in the frames. Provide boxes and lids with a dipped, coal-tar-pitch, varnish finish. Provide lock-type meter boxes when shown on the plans. Ensure the lock mechanisms work with ease.

- 2.17.3.3. **Concrete Meter Boxes.** Furnish concrete meter boxes made of Class "A" concrete conforming to requirements of Item 421. Construct boxes as shown on the plans. Furnish castings that are free from

fractures, large or deep cracks, blisters or surface roughness, or any other defects that may affect serviceability.

2.17.3.4.

Plastic Meter Boxes. Furnish plastic meter boxes made of high-density polyethylene conforming to the ASTM Specifications shown in Table 10.

Table 10
ASTM Test Requirements for Plastic Meter Boxes

ASTM Test	Requirement
D256	Impact Strength = 1.9 ft.-lb./in. (Izod, Notched)
D256	Impact Strength = 6.4 ft.-lb./in. (Izod, Un-Notched)
D638	Tensile Strength (2.0 Min) = 3,400 psi
D648	Deflection Temperature = 170°F
D790	Flexural Modulus = 90,000 psi
D676	Shore D Hardness, 55-65 Impact
	Strength, Falling Dart Method, 100 in.-lb.

Provide meter boxes meeting the following test requirements:

- Static Load: Not less than 2,500 lb. using a 6 in. disc with direct compression exerted at the center of the top of the meter box with a solid plastic lid.
- Deflection: Not less than 1,000 lb. load required to deflect the top edge of the meter box 1/8 in.

Provide a meter box body, without lid, weighing approximately 7 lb.

2.18.

Affidavit of Compliance. Unless otherwise directed, furnish a manufacturer's affidavit of compliance for each of the materials used in this project. Ensure the affidavit certifies that factory inspection and specified tests were performed and that the material furnished complies with the requirements outlined in this specification.

2.19.

Pressure Reducing Station. Unless otherwise shown on the plans, furnish new and unused station piping, valves, and fittings, of the same type as specified on the plans.

Use Class "S" concrete in conformance with Item 421.

Provide reinforcing steel in conformance with Item 440.

Provide a Pressure Reducing Valve (PRV) with a strainer, in the location and arrangement shown on the plans. Provide a valve body made of ductile iron with Class 150 ANSI B16.1 flanges. Provide a valve cover made of ASTM A 48 cast iron. Use Buna-N rubber parts. No leather parts are allowed. Provide a resilient seat with a rectangular cross-section.

Valve internals: Provide a single moving disc and diaphragm assembly. Use a flexible nylon fabric-reinforced elastomer diaphragm integral with assembly. Provide valve internal trim (seat ring, disc guide, and cover bearing) made of stainless steel. Apply a heat fusion bonded epoxy coating to the internal and external surfaces of the valve body including the disc retainer and diaphragm washer. Holiday test the coating applied to the valve body to confirm a minimum even coating of 5-7 mils. Treat the stem with a penetrative salt nitride process. Use a Xylan-coated seat. Leather parts are not allowed. Prepare threaded connections by first using an approved pipe tape.

Furnish control tubing containing shutoff cocks with a "Y" strainer. Equip the valve to allow installing control tubing on either side of the valve. Equip the valve with a valve position indicator.

Ensure the valve and valve box are initially set in the field by an authorized manufacturer's representative. Set the downstream pressure at 60 psi unless otherwise specified. Ensure the PRV includes an adjustable and pressure sustaining pilot system. Use a diaphragm type or piston type valve for the main valve.

Provide Cla-Val Model 90-01BDSYKCKD, Watts ACV Model 115-3M, or approved equal.

Provide a basket strainer upstream of the pressure reducing valve as shown on the plans. Furnish a quick-opening type strainer body, of fabricated steel construction with ANSI Class 150 flanges. Use Type 304 stainless steel for the basket.

Provide a Hayward Model 90, or equal, for PRV's 4 in. to 24 in. When there are space constraints, provide a Hayward Model 510, or equal, for PRV's 14 in. or greater.

- 2.20. **Adjusting Manholes.** Reuse removed manhole and inlet rings, plates, grates, covers, and brick if they are in good condition as determined by the Engineer. Provide additional materials in accordance with Item 465 at no cost to the Department. Single- or multiple-piece prefabricated metal extension rings may be used for the adjustment of manholes as approved. Provide concrete that conforms to the requirements of Item 421.

3. CONSTRUCTION

All construction must conform to the requirements of this Item, the plans and the following Items:

- Item 100, "Preparing Right of Way"
- Item 400, "Excavation and Backfill for Structures"
- Item 402, "Trench Excavation Protection"
- Item 403, "Temporary Special Shoring"
- Item 421, "Hydraulic Cement Concrete"
- Item 465, "Junction Boxes, Manholes, and Inlets"
- Item 476, "Jacking, Boring, or Tunneling Pipe or Box"
- Item 479, "Adjusting Manholes and Inlets"

3.1. Excavation.

- 3.1.1. **Trenches.** Construct water lines and fire hydrant branches (leads) in open cut trenches with vertical sides except in those locations where the pipe is tunneled, cased, or augered. Construct the trenches to the dimensions shown in the excavation and backfill details.

Sheath and brace the trenches to the extent necessary to maintain the sides of the trench in a vertical position throughout the construction period. Protect excavation greater than 5 ft. in depth as specified by Item 402, or Item 403.

Open and excavate the trenches to the finished grade. To allow for possible adjustment of the alignment and grade, locate the water mains to which the mains and fire hydrant branches (leads) under construction are to be connected, well in advance of making connections.

Construct water mains and fire hydrant branches (leads) in dry trenches. If necessary, employ well pointing or additional sheathing to accomplish this objective, at no additional cost to the Department.

For pipes less than 18 in. in diameter, the minimum trench width below the top of the pipe is the outside diameter of the pipe, plus 18 in. For pipes 18 in. and larger, the minimum trench width below the top of pipe is the outside diameter of pipe plus 24 in. Additional width will be required for unstable conditions. The Engineer will determine unstable conditions.

Where it is necessary to excavate trenches adjacent to improved property, take precautions to avoid damaging or impairing that property. Where it is necessary to disturb grass, shrubs, driveways, etc., restore such improvements to their original condition.

Use enough trench width or benches above the embedment zone when installing well point headers or manifolds and pumps, where the trench depth makes it uneconomical or impractical to pump from the surface elevation. Provide enough space between the shoring cross braces to permit equipment operations and handling the forms, pipe, embedment and backfill, and other materials.

Before moving the supports, place and compact the embedment to enough depth to provide protection of the pipe and stability of the trench walls. As the supports are moved, finish placing and compacted the embedment.

Immediately before placing the embedment materials, ensure the bottoms and sidewalls of trenches are free of loose, sloughing, caving, or otherwise unsuitable soil.

Place and compact the embedment materials directly against the undisturbed soils in the trench sidewalls or against sheeting which will remain in place.

Do not place trench shields or shoring within the height of the embedment zone unless using some means to maintain the density of the compacted embedment material. If using moveable supports in embedment zone, lift the supports incrementally to allow placing and compacting of the material against undisturbed soil.

Place haunching material around the pipe and compact it to provide uniform bearing and side support.

Place trench dams in Class I embedments near the midpoint of line segments longer than 100 ft. between manholes.

Where damage to the completed pipe installation work is likely to result from withdrawal of the sheeting, leave the sheeting in place.

3.1.2. **Existing Streets.** Unless otherwise shown on the plans, open cut existing streets.

Where water line construction requires cutting through existing streets outside the limits of new street construction, replace those streets in kind in conformance with the appropriate specifications in the proposal or as directed. When cutting pavement outside the Department's right of way, comply with the Utility Owner Street Cutting Ordinance.

Where, in the opinion of the Engineer, it is necessary to maintain traffic across a trench, construct temporary bridges as necessary to facilitate the movement of traffic.

At locations where the proposed water main parallels the edge of an existing permanent pavement (i.e., concrete pavement, concrete base with asphalt surface, etc.), and is 3 ft. or less from the edge of that pavement, protect the trench with timber sheathing and bracing. Leave the bracing in place at intervals of 5 ft. maximum.

Keep the street surface adjacent to the trench free of surplus spoil. Place construction materials at locations that minimize interference with the traveling public.

Do not close more than 2 street intersections at any one time unless authorized in writing..

3.2. **Jacking, Tunneling, Boring, or Augering.**

3.2.1. **General.** Perform jacking, tunneling, or augering for water mains and fire hydrant branches (leads) at the locations shown on the plans and at other locations specifically designated by the Engineer.

Unless otherwise shown on the plans, use casing pipe conforming to the requirements of Section 2.2.2., "Steel Casing Pipe."

Excavate auger pits to a finished grade at least 6 in. lower than that indicated by the construction stakes or as approved, to ensure that a dry pit bottom is encountered.

Provide a minimum width of jacking, tunneling, or augering pits such that there is at least 6 in. of space between the pipe and the walls of the auger pit. The maximum allowable width of the pit is 5 ft., unless otherwise approved. Ensure the width of the pit at the surface is not less than at the bottom. The maximum

allowable length of the pit is 5 ft. longer than 1 full joint of pipe of the type being used and does not exceed 25 ft., unless approved.

Grout in place tunnels for water lines with 36 in. diameters. When casing size is 48 in. in diameter or greater, or when using a tunnel liner plate, regardless of the water line diameter, grout in place unless otherwise directed. Provide an annular grout consisting of a sand-cement mortar mix with a 28 day compressive strength of at least 1,500 psi, when tested in accordance with ASTM C 942. The maximum allowable density is 130 pcf.

Use admixtures meeting ASTM C 494 and ASTM C 1017 as required, to improve pump ability, control the time of set, hold sand in suspension, and reduce segregation and bleeding. Fill the annular space in 3 lifts to prevent pipe floating. In addition, place appropriate blocking between the carrier pipe and the top of the liner to maintain position. Place a concrete invert to facilitate threading the carrier pipe.

Do not allow inadvertent metallic contact between the casing and the carrier pipe. Place spacers to ensure that the carrier pipe is adequately supported throughout its length, particularly at ends, to offset setting and possible electrical shorting, unless otherwise approved by Engineer. Ensure the end spacer is within 6 in. of the end of the casing pipe, regardless of the size of the casing and carrier pipe or the type of spacer used. Casing spacers are designed to withstand much greater loads than can be safely applied to most coatings. Therefore, the spacing between spacers depends largely on the load bearing capabilities of the pipe coating and the flexibility of the pipe.

Install casing spacers in conformance with the manufacturer's instructions. Use special care to ensure that subcomponents are correctly assembled, evenly tightened, and that no damage occurs while tightening the insulators or inserting the carrier pipe.

Seal the annulus between the carrier pipe and casing with casing end seals at each end of the casing.

Insular Spacing:

- Provide spacing as shown on the plans with a maximum distance between spacers of 10 ft. for pipe sizes for pipe sizes 4 in. to 14 in. and 8 ft. for pipe sizes 16 in. to 30 in.
- For ductile-iron pipe, flanged pipe, or bell-and-spigot pipe, install spacers within 1 ft. on each side of the bell or flange, and one in the center of the joint when 18 ft. to 20 ft. long joints are used.
- If the casing or carrier pipe is angled or bent, reduce the spacing. Provide the casing with a smooth, continuous interior surface.

Perform bedding and backfilling of jacking, tunneling, boring, or augering pits in conformance with the details on the plans and these specifications.

3.2.2. **Jacking Steel Casing.** Perform jacking of steel casing in accordance with the requirements of Item 476.

3.2.3. **Tunneling.** Perform tunneling in accordance with the tunneling requirements of Item 476.

3.2.4. **Boring or Augering.** Perform boring or augering in accordance with the requirements of Item 476.

Do not exceed 100 ft. for the length of the auger hole without a receiving pit.

Do not exceed 75 ft. for the length of the auger hole for PVC pipe 12 in. and less in diameter without a receiving pit.

Do not exceed 40 ft. for the length of the auger hole for PVC pipe 16 in. and greater in diameter without a receiving pit.

At locations where water pipes cross underneath driveways (of 16 ft. or less in width) or sidewalks, install the pipe in tight fitting augered holes.

At locations where the centerline of the proposed water main is 10 ft. or less from the centerline of an 8 in. diameter or larger growing tree, place the pipe in a tight fitting augered hole. Extend the bored hole at least 4 ft. beyond each side of the tree.

Block the void space around the pipe in the augered hole with approximately 12 in. of packed clay or similar approved material, so that the bedding or backfill does not escape into the void around the pipe in the auger hole, when compacted.

Around the pipe, use the minimum volume of the clay or similar acceptable material as shown in Table 11.

Table 11 Volume of Clay or Acceptable Material for Blocking Voids	
Pipe Diameter (in.)	Minimum Quantity (cu. Ft.)
4 through 8	0.5
12 through 16	0.75

3.2.5. **Bedding for Trenches and for Jacking, Tunneling, Boring, or Augering Pits.**

3.2.5.1. **Pipe Bedding for Water Mains Less Than 24 Inches in Diameter.**

3.2.5.1.1. **Open Cut Trench Installation.** Construct trenches with a minimum of 6 in. bedding. Remove the soil in the bottom of the trench, excavate to a minimum depth of 6 in. below the bottom of the pipe, and replace the soil with bedding material. Remove saturated material from the bottom of the pit before placing the bedding. Place the pipe in the bedding such that there is a 6 in. bedding below and up to the spring line of the pipe.

Compact the bedding material to within 95% of the standard density within 5% of the optimum moisture as determined by Tex-113-E. Mechanically compact the bedding material by using vibratory equipment or any other acceptable equipment.

3.2.5.1.2. **Jacking, Tunneling, Boring or Augering Pits.** Construct pits with a minimum of 6 in. bedding. Remove the soil in the pit, excavate to a minimum depth of 6 in. below the bottom of the pipe and replace the soil with bedding material.

If the bottom of the excavation becomes wet due to the presence of groundwater and a dewatering system is not required, and if directed, over excavate an additional 6 in. to a depth of 1 ft. below the bottom of the pipe. Place a non-woven geotextile fabric and then compact 12 in. of bank run sand or concrete sand in a single lift on top of the fabric. Compact the upper 6 in. to 90% of the standard maximum density as determined by Tex-113-E. The Engineer may require the Contractor to remove unstable or unsuitable material, even though the Contractor has not determined the material to be unsuitable.

Mechanically compact the bedding material by using vibratory equipment or any other acceptable equipment. Compact the bedding material to 95% of the standard density within 5% of the optimum moisture, as determined by Tex-113-E.

3.2.5.1.3. **Bedding Materials.** The following describes the acceptable materials for bedding:

- Section 2.14.1., "Bank Run Sand"
- Section 2.14.3., "Pea Gravel"

Bank run sand may be used as bedding material around the pipe only if, as determined by the Engineer, the trench bottom and sides are dry. If sand is used, place the pipe in the bedding so that there is at least 6 in. bedding around and on top of the pipe. Compact the sand as described in Section 3.2.5.1.1., "Open Cut Trench Installation."

3.2.5.2. **Pipe Bedding for Water Mains 24 Inches or Greater in Diameter.**

Open Cut: Provide pipe bedding as described in Section 3.2.5.1., "Pipe Bedding for Water Mains Less Than 24 Inches in Diameter," with the following exceptions: Use bank run sand for the bedding material as described in Section 2.14, "Bedding Material."

Compact cement stabilized sand used as backfill or as pipe bedding as specified on the plans, in 6 in. lifts to 95% of the standard maximum density as determined by Tex-113-E, at the optimum moisture content.

- 3.3. **Handling Pipe and Accessories.** During pipe construction operations, use caution to prevent injury to the pipe, protective linings, and coatings in conformance with the manufacturer's recommendations. Do not place debris, tools, or other materials in the pipe.

Repair any damage to the pipe or the protective lining and coating from any cause during the installation of the pipeline and before final acceptance by the purchaser. Perform this work as directed, in conformance with the applicable standards, and at no cost to the Department.

Unload pipe, fittings, valves, and accessories at the point of delivery and haul them to the project site. Distribute the material opposite or near the place where it will be laid in the trench such that storm water or runoff will not enter or pass through the pipe. Do not drop the materials. Do not allow pipe handled on skid ways to be skidded or rolled against pipe already on the ground.

Load, transport, unload, and otherwise handle pipe and fittings in a manner and by methods which prevent damage of any kind. Handle and transport pipe with equipment designed, constructed, and arranged to prevent damage to the pipe, lining, and coating. Do not allow bare chains, hooks, metal bars, or narrow skids or cradles to come in contact with the coatings. Provide pipe fittings with enough interior strutting or cross-bracing to prevent deflection under their own weight.

Hoist the pipe and fittings from the trench side into the trench by means of a sling of smooth steel cable, canvas, leather, nylon, or similar material. Do not lift pipe by using hooks at each end of the pipe. When stacking pipe, ensure it is packaged on timbers. Place protective pads under the banding straps at the time of packaging.

When using fork trucks to relocate pipe, pad the forks using carpet or some other suitable type of material. When relocating pipe using a crane or backhoe, use nylon straps or smooth steel cable, do not use chains, around the pipe for lift.

- 3.4. **Cutting Pipe.** Cut pipe 12 in. in diameter and smaller in conformance with the manufacturer's recommendations. Cut pipe larger than 12 in. in an approved manner. Perform each cut at right angles to the axis of the pipe and file or grind to remove sharp edges. Use a cutting machine unless otherwise approved by Engineer. Do not damage pipe or linings and coatings, while cutting.

- 3.5. **Defective or Damaged Material.** Inspect pipe and accessories for defects before lowering into the trench. Repair or replace any defective, damaged, or unsound material as directed.

If a damaged piece of pipe, furnished by the Contractor, is placed in the water main, furnish the labor and materials necessary to remove and replace the defective pipe and to restore the street to its original condition at no cost to the Department. If the Contractor damages the pipe after installation, the Engineer may permit the damaged section to be cut from the length, unless it is the opinion of the Engineer that the entire length was damaged. The cost of and replacement of broken pipe is at the expense of the Contractor.

- 3.6. **Cleaning Pipe and Accessories.** Remove lumps, blisters, and excess coating from the bell and spigot ends of steel pipe, ductile-iron pipe, valves, hydrants, and fittings. Wire brush the outside of the spigot and the inside of the bell and wipe clean, dry, and free from oil and grease before laying the pipe.

Remove foreign matter or dirt from the interior of water pipe, accessories, and from the mating surfaces of the joints, before lowering the material into the trench. Keep the pipe and accessories clean during and after laying by approved means.

Use cleaning solutions, detergents, solvents, etc. with caution when cleaning PVC pipe.

Provide cleanup and restoration crews to work closely behind the pipe laying crews, and where necessary, during disinfection, testing, service transfers, abandonment of old mains, backfilling, and surface restoration.

Upon completely installing a section not exceeding 4,000 ft. per crew, immediately prepare to disinfect and pressure test between valves or plugs. No later than 3 days after completing disinfection preparatory work, submit to the Utility Owner an appropriate request for disinfection.

Begin transfer of services no later than 7 calendar days after successfully completing the disinfection and pressure testing.

Immediately after transfer of services, begin abandonment of the old mains, including re-sodding and placing sidewalks and pavements.

Do not begin construction of additional sections if the above conditions are not met.

For large diameter water mains, do not install more than 2,000 ft. of main, until the previous 2,000 ft. is cleaned up and the site is fully restored. Schedule paving crews so that the repaving work will not lag behind the pipe laying work by more than 1,000 ft.

Completely restore the site within 30 days from the date the water main is successfully disinfected and hydrostatically tested, unless extended in writing by the Engineer.

For projects involving multiple locations, limit water main installation to a maximum of 2 project site locations.

Remove construction debris or foreign material and thoroughly clean and flush piping systems as approved. Provide temporary connections, equipment, and labor for cleaning. The Engineer must inspect the water main for cleanliness before filling.

Disinfection of Water Lines: Conform to the requirements of Section 3.17., "Disinfecting Mains and Testing for Leakage."

- 3.7. **Laying Pipe.** For the work of laying the pipe, employ only workers who are skilled and experienced in laying pipe of the type and joint configuration being furnished. Provide watertight pipe and pipe joints. Lay pipe with the bell ends facing in the direction of laying, unless otherwise directed.

Lay pipe to the lines and grades shown on the plans. To ensure proper placement, use adequate surveying methods and equipment, and employ personnel competent in using this equipment. Ensure the pipe does not deviate from the horizontal and vertical alignment indicated on the plans by more than 0.10 ft., without prior approval. Measure and record the "as-built" horizontal alignment and vertical grade at a maximum of every 50 ft. on the on-site recorded plans.

During pipe laying operations, keep pipe trenches free of water which might impair the laying operations. Ensure holes for bells are of ample size to prevent the bells from coming in contact with the subgrade. Carefully grade pipe trenches to provide uniform support along the bottom of the pipe.

Do not lay more than 50 ft. of pipe in the trench ahead of the backfilling operations. If pipe laying operations are interrupted overnight, cover the pipe laid in the trench simultaneously on each side of the pipe or completely backfill, to avoid lateral displacement of the pipe and damage to the joints. If adjustment of the position of a length of pipe is required after it is laid, remove and re-lay it in conformance with these specifications and at no expense to the Department. After pipe laying and joining operations are complete, clean the inside of the pipe and remove debris.

Use care to prevent damage to the coating when placing backfill. Backfill in accordance with Section 3.11, "Backfilling."

Lay pipe in a straight line unless otherwise shown or approved. Long radius curves, either horizontal or vertical, may be laid with standard pipe using deflections at the joints. If curved pipe is shown, needing no special fittings, the curves can be made by deflection of the joints with standard lengths of pipe as approved. If maximum pipe joint deflections are permitted, do not exceed the manufacturer's recommendation for maximum pipe joint deflections. Joint the gasketed pipe in a straight alignment and then deflect it to the curved alignment.

If the vertical deflection exceeds the maximum recommended by the manufacturer, remove the entire portion of the deflected pipe section and install new pipe as directed. Perform this work at no expense to the Department. The Engineer may measure assessment of deflection at any location along the pipe. Arithmetical averages of the vertical deflection or similar average measurement methods will not be deemed as meeting the intent of the standard.

Where field conditions require horizontal deflection curves not shown on the plans, the Engineer will determine the methods to be used.

No additional payment will be made for laying pipe on curves as shown, or for change orders involving standard lengths of pipe deflected at the joints. Adjust the pipe, valves, hydrants, and fittings to be at their proper locations and prepare each joint as specified in Section 3.8., "Joining Pipe and Accessories." As each joint of pipe is laid in the trench, center the spigot end in the bell of the previously laid pipe, then force home the pipe and bring it to the correct line and grade. Ensure each length of pipe rests on the bottom of the trench and is inspected for damage throughout its entire length.

When pipe laying is discontinued for the day or for an indefinite period, tightly place a cap or plug in the end of the last pipe laid to prevent the intrusion of water. When water is excluded from the interior of pipe, place enough backfill on the pipe to prevent floating. Schedule the work to prevent the possibility of floatation. Remove from the trench any pipe that has floated and re-lay as directed.

When assembling PVC pipe on top of the trench, allow it to cool to ground temperature before backfilling, to prevent pull-out due to thermal contraction.

Do not schedule night works or plant shut down to begin within 2 working days before or after Utility Owner-designated holidays.

For tie-ins to existing water mains, provide the necessary material on-hand to facilitate connection before shutting down the existing water main.

Ensure that separation from gravity sanitary sewers and manholes, or from force mains, is a minimum of 9 ft. clearance in all directions or as specified, unless a special design is shown on the plans.

Minimum Clearance of this specification:

- Parallel water line and gravity sanitary sewer force main, or manhole with no leaks:
Minimum 4 ft. horizontal clearance from the outside wall of the water line to the outside wall of the gravity sanitary sewer, force main, or manhole.
- Water line crossing above gravity sanitary sewer or force main with no leaks:
Minimum 2 ft. vertical clearance.
- Water line crossing below a sanitary sewer or force main with no leaks:
Minimum 2 ft. vertical clearance.

3.8. **Joining Pipe and Accessories.**

- 3.8.1. **Ductile-Iron Pipe, Valves, Hydrants, and Fittings.** After thoroughly cleaning the inside of the bell and the outside of the spigot, install members in conformance with the manufacturer's recommendation and AWWA C600, or as modified by these specifications.

Mark pipe and accessories that are not furnished, with a depth mark before assembly to ensure that the spigot end is inserted to the full depth of the joint.

Brace the fittings on small mains with short pieces of 2 in. galvanized pipe as directed.

Brace each plug installed under this contract by a standard pipe clamp, a 3 ft. nipple of the same diameter pipe as the nearby sections of mains, and a block of concrete.

For 4 in. through 12 in. water mains, use pipe clamps that are Underwriters Lab-approved for underground water service piping. For water mains 16 in. and larger, use pipe clamps conforming to details shown on the plans.

For rubber-gasketed joints use lubrication that is water soluble, non-toxic, non-objectionable in taste and odor imparted to the fluid, non-supporting of bacteria growth, and has no deteriorating effect on coatings or rubber gaskets.

- 3.8.2. **Polyvinyl Chloride Pipe and Accessories.** Join plastic pipe in conformance with the instructions furnished by the manufacturer. To prevent weakening the joint, do not handle or install in the trench pipe joined using solvent cementing techniques, until the joints "cure."

For rubber-gasketed joints, use lubrication that is water soluble, non-toxic, non-objectionable in taste and odor imparted to the fluid, non-supporting of bacteria growth, and has no deteriorating effect on PVC or rubber gaskets.

- 3.8.3. **Welded Joints for Steel Pipe.** Ensure the joints receive a full-penetration butt weld type double weld, in accordance with AWWA C206. It is the Contractor's option to use either automatic or hand welders. Before starting the work, provide proof of certification of qualification for welders employed on the project for every type of work procedure and position involved. Ensure qualification is in accordance with AWWA C206. Ensure complete penetration of deposited metal with the base metal. Provide inside fittings and joints that are free from globules of weld metal that would restrict flow or become loose.

Miter end cuts of both ends of butt-welded joints may be used for joint deflections of up to 2.5°.

Set fittings and joints square and true, and preserve the alignment during welding operations. Align the butting ends to minimize the offset between surfaces. For pipe of the same nominal wall thickness, do not exceed 1/16 in. offset. Use line-up clamps for this purpose; however, exercise caution to avoid damaging to the linings and coatings.

Furnish each welder employed with a steel stencil for marking welds, so the work of each welder can be identified. Mark pipe with the assigned stencil adjacent to the weld. If a welder leaves the job, void that stencil and do not duplicate it. Welders making defective welds must discontinue work and leave the project site. Such welders may return to the project site only after recertification.

During welding, protect the lining by draping an 18 in. wide strip of heat-resistant material over the top half of the pipe on each side of the lining holdback to avoid damage to the lining by the hot splatter. Protect the tape coating similarly.

Provide welding rods of a type compatible with the metal being welded, to obtain the strongest bond, E-70XX.

Deposit the metal in successive layers so there will be at least 2 passes or beads for automatic welding and 3 passes or beads for manual welding in the completed weld.

On welds, do not deposit more than 1/4 in. of metal on each pass. Thoroughly clean the weld by wire brushing and hammering on each individual pass including the final one, to remove dirt, slag, or flux.

Do not perform welding under any weather condition that would impair the strength of the weld, such as wet surface, rain or snow, dust or high winds, unless the work is properly protected.

If using tack welds, ensure they are of the same material and made by the same procedure as the completed weld. Otherwise, remove tack welds during the welding operation.

Remove dirt, scale, and other foreign matter from the inside of piping before tying in sections, fittings, or valves.

Provide a minimum overlap of 4 in. of butt strap over the adjacent piece on butt strap closures.

Employ an approved independent certified testing laboratory, to perform weld tests and associated work to accommodate testing on the entire job. Include the cost of such testing in the contract unit bid price for the water main. Furnish copies of test reports to the Engineer for review. Ensure testing is by X-ray methods for butt welds and is performed for every joint weld. If a defective weld is revealed, assume the cost of repairing and retesting the repaired weld. The Engineer has the full and final decision as to the suitability of welds tested. If any interior or exterior coating or lining is damaged during the welding process, repair it and return it to its original state as approved, in conformance with applicable AWWA standards.

Provide cylindrical corrosion barriers (CCBs) for epoxy-lined steel pipe smaller than 24 in. in diameter. Furnish CCBs manufactured by CCB International, Inc., or approved equal. CCBs are not required if the minimum wall thickness is 1/2 in. or greater.

In addition to the welding requirements contained in this specification, conform to the protection fitting manufacturer's installation recommendations.

Provide the services of a technical representative of the manufacturer available on site at beginning of pipe laying operations. Ensure this representative is able to train welders and advise regarding installation and general construction methods. Employ only welders with at least 12 mo. experience installing protection fittings.

3.8.4.

Flanged Joints for Steel Pipe. Before installing bolts, accurately center the flange joints and align them to prevent mechanical pre-stressing of flanges, pipe, and appurtenances. Align bolt holes to straddle the vertical, horizontal, or north-south, centerline. The maximum inclination of the flange face from the true alignment is 3/64 in. per foot.

Use full-face gaskets for flanged joints. Provide 1/8 in. thick cloth inserted rubber gasket material. Cut the gaskets at the factory to the proper dimensions.

Unless otherwise noted, provide insulation kits at connections to the existing water system or at locations to isolate one type of cathodic system from another type; between water line, access manhole piping, and other major openings in the water line; or as shown on the plans.

For isolating flange joints 30 in. in diameter and greater, and at butterfly valve flanges, provide a Pyrox G-10 with nitrite seal, Type E LineBacker gasket as manufactured by Pipeline Seal and Insulator, Inc., or approved equal, conforming to ANSI A 21.11 mechanical joint gaskets. For isolating flange joints 24 in. in diameter and smaller, provide a Phenolic PSI with nitrite seal, Type E LineBacker gasket as manufactured by Pipeline Seal and Insulator, Inc., or approved equal, conforming to ANSI A 21.11 mechanical joint gaskets.

Use galvanized or black nuts and bolts to match the flange material. Use cadmium-plated steel nuts and bolts underground. Tighten the bolts progressively to prevent unbalanced stress. Consistently maintain approximately same distance between the two flanges at all points around the flanges. Tighten the bolts alternately (180° apart) until they are evenly tight. Draw the bolts right to ensure properly seating the gaskets. Provide Denso, or approved equal, petroleum-based tape wrapping system for nuts and bolts.

Pay particular attention to procedures used in tightening and torqueing flanged joints. Improper methods may result in leakage and require corrective measures. Follow recommended industry standards and guidelines as set forth by the various fabricators and manufacturers.

- 3.8.5. **Flanged Joints For Use On Ductile-Iron Pipe.** See the requirements of Section 3.8.4., “Flanged Joints for Steel Pipe.”

- 3.9. **Thrust Restraint.** Provide adequate temporary blocking of fittings when making connections to the distribution system and during hydrostatic tests. Provide enough anchorage and blocking to resist stresses and forces encountered while tapping the existing waterline. For new waterlines 16 in. in diameter and larger, provide restraining joints as specified in this section. Provide restrained joint lengths as shown on the plans or as directed. For existing waterlines and waterlines less than 16 in. in diameter, restrain pipe joints with concrete thrust blocks or provide joints as specified in this section.

The length of the restrained joints shown on the plans, assumes that hydrostatic testing will begin upstream and proceed downstream with respect to the normal flow of the water in the pipe. If installation or testing of the pipe differs from this assumption, submit for approval a revised method of restraining the pipe joints upstream and downstream of the device used to test against (i.e., block valve, blind flange, or dished head plug).

- 3.10. **Electrical Continuity Bonds.**

- 3.10.1. **General.** Attach the bond wires at the required locations using the Thermite welding process.

- 3.10.2. **Thermite Welding Methods.** Perform Thermite welding of bond wires to the piping in the following manner:

Ensure the pipe to which the wires will be attached is clean and dry. Use a grinding wheel to remove coating, mill scale, oxide, grease, and dirt from an area approximately 3 in. square. Grind the surface to bright metal.

Remove approximately 1 in. of insulation from each end of the wires to be Thermite welded to the structure, exposing clean, oxide-free copper for welding.

Select the proper size Thermite weld mold as recommended by the manufacturer. Place the wire between the graphite mold and the prepared metal surface. For No. 12 AWG size wires, use a copper sleeve crimped over the wire. Place the metal disk in the bottom of the mold. Place the Thermite weld charge in the mold. Squeeze the bottom of the cartridge to spread ignition powder over the charge.

Close the mold cover and ignite the starting powder with a flint gun. After the exothermic reaction, remove the Thermite weld mold and gently strike the weld with a hammer to remove the weld slag. Pull on the wire to assure a secure connection. If the weld is not secure or the wire breaks, repeat the procedure with a new wire. If the weld is secure, coat bare metal and weld metal with a coal-tar compound. If a polyurethane dielectric coating has been used, use a compatible polyurethane coating.

- 3.11. **Backfilling.**

- 3.11.1. **General.** Backfill trenches in accordance with the requirements of Item 400.

Begin backfilling and cleaning up each section of main, i.e., from valve to valve, immediately upon the completing the hydrostatic test, unless otherwise permitted by Engineer, and continue until obtaining a final and complete clean-up of the section. Any portion of the trench that is left open in excess of that required to facilitate hydrostatic testing may be ordered closed by the Engineer.

Use surplus excavated materials in the embankments or dispose of them as directed.

- 3.11.2. **Backfilling Pipe for Water Mains.**

- 3.11.2.1. **Open Cut.** After the pipe joints are made up and inspected, backfill the trenches with excavated materials or any other backfill material covered by this specification, as approved. Backfill the portion from the spring line of the pipe (or from 6 in. on top of pipe if sand bedding is used) to the top of the trench in maximum lifts of 9 in. loose measurement (provided the trench is not located in sidewalks, roadways, roadway shoulders, driveways, etc. that are being used for automobile or pedestrian traffic). Mechanically compact the backfill material using vibratory equipment, or any other acceptable equipment, so that no settlement occurs. Compact to a density of at least 95% of the maximum dry density, as determined in accordance with Tex-114-E. The Engineer reserves the right to perform compaction tests on an as-needed basis. Compaction by water tamping is prohibited.

Do not allow dirt, clods, or trench sides to fall or rest against the pipe before completing the embedment or backfill.

The allowable materials for backfill are listed in Section 2.15, "Backfill Material."

Continue backfilling and compacting in this manner to the minimum elevation shown in the excavation and backfill diagram.

- 3.11.2.2. **Boring or Augering Pits.** Backfill boring or augering pits with bank run sand up to 1 ft. from the top of the natural ground. For the final 12 in., use backfill consisting of 10 in. of native soil in the bottom and 2 in. of bank run sand just below the grass.

Backfill the portion from the spring line of the pipe to the top of the pit in lifts not exceeding 9 in. (loose measurement). Mechanically compact the backfill by using vibratory equipment, or any other acceptable equipment, so that no settlement occurs. Compact the material to a density of at least 95% of the maximum dry density at optimum moisture content as determined in accordance with Tex-113-E or Tex-114-E. The Utility Owner may perform compaction tests on an as-needed basis. Compaction by water tamping is prohibited.

Do not allow dirt, clods, or auger pit sides to fall or rest against the pipe before completing the embedment or backfill.

The only allowable material for backfill in boring or augering pits is bank run sand, described in Section 2.15, "Backfill Material."

- 3.12. **Valves and Fire Hydrants.** Ensure each valve and fire hydrant is completely closed when placed in the pipe line.

Install valves and hydrants in accordance with AWWA C600, except where modified by this specification. Provide drainage at the base of the hydrant in accordance with AWWA C600.

Set each hydrant at the location and grade indicated by the stakes, and plumb, brace, and install in accordance with AWWA's requirements for fire hydrant installation. If the barrel of a hydrant is to pass through a concrete slab, fit a piece of 1 in. thick pre formed bituminous expansion joint material closely around the section of the barrel passing through the concrete.

Locate the nozzle centerline a minimum of 18 in. above the finish grade.

Place 12 in. x 12 in. yellow indicators (plastic, sheet metal, plywood, or other approved material) on pumper nozzles of new or relocated fire hydrants installed on new mains not in service. Remove indicators after the new main is tested and approved.

- 3.13. **Tapping Sleeves and Valves.**

- 3.13.1. **General.** Install tapping sleeves and valves at the locations and using the sizes shown on the plans. Thoroughly clean the tapping sleeve, tapping valve, and pipe in conformance with the manufacturer's instructions before installing.
- Hydrostatically test the installed tapping sleeve to 150 psig for a minimum of 15 minutes. Inspect the sleeve for leaks, and remedy any leaks before the tapping operation.
- When tapping concrete pressure pipe, size on size, use a shell cutter one standard size smaller than that of the water line being tapped. Do not use Large End Bell (LEB) increases with a next size tap except for existing asbestos-cement pipe.
- 3.13.2. **Installation.** Verify the outside diameter of the pipe to be tapped before ordering the sleeve. Tighten the bolts in the proper sequence to avoid placing undue stress on the pipe. Align the tapping valve properly and attach it to the tapping sleeve. Insert the insulation sleeve into the flange holes of the tapping valve and pipe. Insert the sleeve on pipe side of tapping valve. Do not damage insulation sleeves during the bolt tightening process.
- Make the tap with a sharp shell cutter using the following criteria: For 12 in. and smaller taps use a minimum cutter diameter 1/2 in. less than the nominal tap size. For 16 in. and larger taps, use the manufacturer's recommended cutter diameter.
- Withdraw the coupon and flush the cuttings from the newly-made tap. For 12 in. and smaller taps, wrap the completed tapping sleeve and valve in accordance with this specification.
- For 16 in. and larger taps, apply Denso or approved equal, petroleum-based tape wrapping system around the completed tapping sleeve and valve. Place the concrete thrust block behind the tapping sleeve (not over the tapping sleeve and valve).
- Arrange for the mandatory inspection of the installation before backfilling. Completion of the inspection is not required before backfilling. Backfill in accordance with this specification and as shown on the plans.
- If Asbestos-Cement (AC) Pipe is encountered, follow the Safety Practice outlined in the Asbestos-Cement Pipe Producers Association publication, "Recommended Work Practices for A/C Pipe," and make them "Mandatory Practices" for this project.
- 3.14. **Boxes for Valves.** Cut the cast-iron or ductile-iron pipe to the proper length, then assemble and brace the box as approved. Construct manholes over the operators of butterfly valves for sizes 30 in. and larger.
- Concrete for valve box placement: For locations in new concrete pavement, use the same strength and mix design as that of new pavement. For other locations, use Class "A" Concrete, conforming to the requirements of Item 421.
- Install valve box and riser piping plumbed in a vertical position. Provide 6 in. telescoping freeboard space between the riser pipe top butt end and the interior contact flange of the valve box, for vertical movement damping. Ensure the riser (bell end of pipe) rests on the valve flange, or provide a suitable foot piece to support the riser pipe.
- Set, align, and adjust the valve box so that the lid is level with the final grade.
- Paint the covers of new valve boxes in "Fluorescent Orange" when installed. After completion and approval by the Engineer, repaint the covers in "Black."
- 3.15. **Wet Connections.** Make the wet connections, as directed, in such a manner and at such hours to minimize inconvenience to the public. When the existing mains have been cut or a plug removed for a connection, pursue the work of making the connection without interruption until complete.

If the Contractor proceeds with a wet connection without a complete shut-off, there will be no extra compensation for damages or extra work resulting from the incomplete shut-off.

The Utility Owner will operate gate valves in the existing system and in sections of completed mains that have been placed in service. Notify the Utility Owner at least 48 hr. in advance of making connections.

Wet connections that are 2 in. or smaller are sometimes referred to on the plans as 2 in. standard connections or gooseneck connections.

Items that may be necessary to complete these types of wet connections include corporation cock, saddle, copper tubing, brass fittings, and 2 in. valves. Do not use these connections on or consider them as part of a 2 in. service line.

The Utility Owner will handle, at no cost to the Contractor, operations involving opening and closing valves for wet connections.

- 3.16. **Polyethylene Film Wrap.** Except as noted on the plans, wrap ductile-iron pipe (including fittings and other appurtenances), with a polyethylene film. Also wrap fire hydrant barrels.

Remove lumps of clay, mud, cinders, etc., on the pipe surface before installing the polyethylene encasement. Prevent soil or embedment material from becoming trapped between the pipe and the polyethylene. Fit the polyethylene film to the contour of the pipe to affect a snug, but not tight fit; encase with minimum space between the polyethylene and the pipe. Provide enough slack in contouring to prevent stretching the polyethylene where it bridges irregular surfaces, such as bell-spigot interfaces, bolted joints, or fittings, and to prevent damage to the polyethylene due backfilling operations. Secure overlaps and ends with adhesive tape to hold polyethylene encasement in place until backfilling operations are complete.

For installations below the water table and in areas subject to tidal actions, seal both ends of the polyethylene tube with adhesive tape at the joint overlap.

Repairs: Repair any cuts, tears, punctures, or damage to the polyethylene with adhesive tape or with a short length of polyethylene sheet or cut open tube, wrapped around the pipe to cover the damaged area, and secured in place.

Openings in Encasement: Provide openings for branches, service taps, blow offs, air valves, and similar appurtenances by making an X-shaped cut in the polyethylene and temporarily folding back the film. After the appurtenance is installed, tape the slack securely to the appurtenance and repair the cut, as well as other damaged areas in the polyethylene, with tape. Service taps may also be made directly through the polyethylene. Repair any resulting damaged areas as described above.

Junctions between Wrapped and Unwrapped Pipe: Where polyethylene-wrapped pipe joins an adjacent pipe that is not wrapped, extend polyethylene wrap to cover the adjacent pipe for distance of at least 3 ft. Secure the end with circumferential turns of tape. Wrap service lines of dissimilar metals with polyethylene or suitable dielectric tape for a minimum clear distance of 3 ft. away from cast-iron or ductile-iron pipe..

- 3.16.1. **Tubular Type Wrap.** When the polyethylene film is supplied in tubular form, install it on the pipe before placing the pipe in the trench and in the following manner:

Elevate the spigot end of the pipe, brush mud and debris from the pipe, and slip a length of film (approximately 2 ft. longer than the joint of pipe) over the joint of the pipe. Wrap the film tightly around the spigot end, leaving about 1 ft. extending beyond the end of the pipe, and tape the edge down lightly with polyethylene tape.

When lifting the joint of pipe for placing in the trench, remove any remaining mud, clay, or debris. Insert the spigot end into the bell end of the joint previously placed, push home, and release the pipe into the trench. Pick up the pipe joint at the bell, slide the film to a point back of the bell, and prepare a bell hole.

When laying the next joint, pull the film beyond the bell to overlap the film attached to the spigot of the new pipe joint. Wrap the film by folding it longitudinally and tape it securely in place to prevent damage during backfill. Do not tape the end that is slipped over the last bell but bind it with twine or other approved material.

At each corporation, draw the loose material up around the corporation base and seal it with tape to insulate the 2 dissimilar metals.

Wrap fittings and fire hydrant leads, and tape or bind the wrap with heavy twine. Wrap fittings, such as bends and reducers, similarly to the method outlined above. Wrap specials, such as valves, tees, crosses, etc., by splitting, tucking, and overlapping the polyethylene tube, then closing the field-made splices with the required tape. Material to cover the valves may be acquired from excess overlapping polyethylene tubing on adjacent pipe joints. Draw the polyethylene tubing over the bell of the pipe on either side and insulate with field-made seams as described above. Completely wrap fittings and specials that require concrete blocking, before placing concrete.

- 3.16.2. **Sheet Type Wrap.** Apply sheet type wrap around the pipe either before or after positioning the pipe in the trench. Install "above ground" in a manner similar to that described above for tubular installation. Install "in trench" in a manner similar to that described below:

Cut the polyethylene sheet to a length approximately 2 ft. longer than the pipe section. Center the length to provide a 1 ft. overlap on each adjacent pipe section, bunching it until it clears the pipe ends. Wrap the polyethylene around the pipe so that it circumferentially overlaps the top quadrant of the pipe. Secure the cut edge of the polyethylene sheet at intervals of approximately 3 ft.

Lower the wrapped pipe into the trench and make up the pipe joint with the preceding section of pipe. Make shallow bell holes at joints to facilitate installation of the polyethylene. After completing the joint, make the overlap and secure the ends.

Repair cuts, tears, punctures, or other damage to the polyethylene. Proceed with installing the next section of pipe in the same manner.

- 3.16.3. **Boring or Augering Section Installation.** Use cast-iron or ductile-iron pipe with a polyurethane coating as specified in this Specification.

Provide a final seal against the intrusion of the backfill material by completely encasing the tapping sleeve with sheet vinyl of 8 mil thickness. Apply tape to secure this wrapping, using Polyken No. 900, Scotch Wrap No. 50, or approved equal, manufactured for this purpose.

- 3.17. **Disinfecting Mains and Testing for Leakage.**

- 3.17.1. **Disinfecting Mains.** The Utility Owner will furnish water for disinfecting and flushing without charge to the Contractor.

Furnish the necessary taps, risers, and jumpers of such sizes and materials as are specified by the Engineer, and install the subject material in the locations designated. Normally, each valve section of main will require two 3/4 in. taps; however, on larger mains the Engineer may order that 1-1/2 in. or 2 in. taps and risers be used.

Furnish and install the necessary temporary blind flanges, sleeves, plugs, etc., as required to disinfect and pressure test the new mains.

Use fire hydrants as blow-offs to flush newly constructed waterlines 8 in. diameter and above.

After laying and backfilling the pipe, disinfect the newly laid pipe. Unless otherwise shown on the plans, the Utility Owner will furnish and pay for the labor and materials necessary for the initial application of the disinfecting agent. Slowly fill each valves section of pipe with water and expel the air from the pipe. Furnish

and install taps at the points of highest elevation, if required to accomplish this. After filling the main with water and expelling the air, charge the pipe with the disinfecting agent and allow it to stand for 24 hr. Unless otherwise shown on the plans, the Utility Owner will then flush the main with water. After flushing, draw samples from the main and test for 2 consecutive days at a valid, approved testing facility. After samples are drawn and the test results pass, proceed with the pressure test and any necessary repairs. If the samples do not pass, re-disinfect the pipe until the samples taken are passed by the certified and approved testing facility. Unless otherwise shown on the plans, in the event that more than one disinfection of the main (or portion of the main) is required, the additional disinfection will be charged to the Contractor at rates established by the Utility Owner.

After disinfecting and flushing water lines, bacteriological tests will be performed by the Utility Owner or testing laboratory.

When test results indicate a need for additional disinfection of water lines based on Texas Department of Health requirements, assist Utility Owner with additional disinfection operations.

- 3.17.2. **Testing for Leakage.** Following the first disinfection test, subject the newly laid pipes to a hydrostatic pressure of 125 psi, unless otherwise shown on the plans. Where practicable, test pipe lines in lengths between line valves or plugs, of at most 1,500 ft. unless otherwise approved. Perform the pressure test by means of a pump connected to the pipe in a manner satisfactory to the Engineer. Furnish, install, and operate the necessary connections, pump, meter, and gauges. Before running the pressure test, ensure the meter is tested, sealed, and approved (at the Contractor's expense) by an approved, certified testing facility. Ensure the minimum duration of the test is 8 hr. If a large quantity of water is required to maintain pressure during the test, discontinue testing until the cause of the water loss is identified and corrected.

Observe the following general regulations during each leakage test for cast-iron, ductile-iron, and PVC pipe:

Except for welded steel pipe in which no leakage is permitted, ensure that pipe lines, when subjected to the specified pressure test, do not show leakage in excess of 3.19 gal. per inch of diameter, per mi., in 24 hrs.

Repair portions of the pipe showing visible leaks regardless of the total leakage shown by the pressure test. Remove and replace cracked or defective pipes, fittings, valves, or hydrants discovered by means of this pressure test with sound material. If the main is opened for any reason, re-disinfect it until satisfactory samples are obtained. Also, pressure test it until the requirements of this specification are met.

Immediately upon completing disinfection and pressure testing, remove all taps, risers, and blow-offs, then backfill the remainder of the trench in accordance with the requirements of this specification.

Perform leakage testing at no additional cost to the Department.

- 3.18. **Using Completed Sections of Mains.** The Utility Owner may use and operate portions of the water mains that are disinfected and pass the leakage test. Unless otherwise shown on the plans, operate the valves in such completed sections only with the express permission of the Utility Owner.

The use of the mains is not construed as acceptance of them and does not relieve the Contractor's responsibility for fulfilling the conditions of the contract, unless the mains are damaged due to negligence on the part of the Utility Owner.

- 3.19. **Lowering Mains.** When lowering a main, perform the initial excavation in such a manner to permit the mains to rest on a number of dirt benches. If soil conditions are unsatisfactory for dirt benches, use wooden blocks to support the mains. Then attach the pipe by using ropes, cable, or chains to overhead supports; remove the dirt benches or wooden blocks, and slowly and evenly lower the pipe into position. After lowering the mains, repair each damaged joint as directed.

- 3.20. **Copper Service Line Construction.** The use of Hays-Seal and Mueller Company catalog numbers to describe various fittings is not intended to be proprietary, but merely to indicate clearly the respective types of fittings to be furnished.

- 3.20.1. **Installing Service Lines.** For curb and gutter streets, lay copper service lines with a minimum 30 in. of cover from top of curb to the top of the service line. For crowned streets with open ditches, lay copper service lines with a minimum 30 in. of cover at the crown and with a minimum 18 in. of cover from the flow line of the ditch to the top of the service line. Ensure service line locations are clear of proposed paving and underground work.

Exercise caution to keep the lines free of dirt and foreign matter at all times. Assemble copper lines in an entirely slack position and free of kinks. Use service lines consisting of one continuous run of copper tubing where possible. Do not use bends greater than that originally found in the coil of tubing as packaged.

For 1-1/2 in. and 2 in. copper tubing shipped in straight lengths, use the following bend criteria:

For 2 in. copper tubing, a maximum of one 45° bend may be accomplished in a 4 ft. section; for 1-1/2 in. copper tubing, a maximum of one 45° bend in a 3 ft. section. No kinks, dents, flats, or crimps will be permitted.

Locate meters, in general, 1 ft. into the street right of way. Where this is not applicable, locate meters approximately 1 ft. from the sidewalk on the curb side. If the present meter location conflicts with proposed driveway turnouts or other proposed street improvements, shift the meter to miss the obstruction and reconnect it to the customer's service line. Reset meters at positions such that the top of the meter is 4 in. to 6 in. below the finished grade.

Where the plans call for salvaging and relocating the meter, meter box, and curb stop, remove these materials with care, thoroughly clean them, and submit them for inspection by the Engineer, before installing them in the new location. If the plans call for relocating the meter (other than at some point along the existing service line), a new service line will be required.

Where it is necessary to cross a paved street, push the service line under the paving through a pre-drilled and prepared opening. Use only full lengths of copper tubing, taking care not to damage the tubing when pulling it through the prepared hole.

A compression type union is only permitted when a full 40 ft. (60 ft. for 3/4 in. to 1 in.) length of tubing cannot completely span underneath the pavement. Do not use compression type unions under the paved street.

- 3.20.2. **Installing Corporation Stops.** Tap the main at a location such that a straight line passing through the meter and the corporation stop will be at 90° to the main. Locate taps in the upper portion of the main within 45° of the pipe spring line. Perform the cutting operation with an approved sharp shell cutter tool.

Install taps for service lines conforming to the requirements of Table 12. Space taps a minimum of 2 ft. apart.

Table 12
Service Tap Requirements for Service Lines

Water Main Type and Diameter	Service Size Diameter			
	3/4 in.	1 in.	1-1/2 in.	2 in.

4 in. Cast-Iron or Ductile-Iron	DSS, WBSS	DSS, WBSS	DSS, WBSS	DSS, WBSS
4 in. Asbestos-Cement	WBSS	WBSS	DSS, WBSS	DSS, WBSS
4 in. PVC (AWWA C 900)	DSS, WBSS	DSS, WBSS	DSS, WBSS	DSS, WBSS
6 in. and 8 in. Cast-Iron or Ductile-Iron	DSS, WBSS	DSS, WBSS	DSS, WBSS	DSS, WBSS
6 in. and 8 in. Asbestos-Cement	DSS, WBSS	DSS, WBSS	DSS, WBSS	DSS, WBSS
6 in. and 8 in. Cast-Iron or Ductile-Iron	DSS, WBSS	DSS, WBSS	DSS, WBSS	DSS, WBSS
6 in. and 8 in. PVC (AWWA C900)	DSS, WBSS	DSS, WBSS	DSS, WBSS	DSS, WBSS
12 in. Cast-Iron or Ductile-Iron	DSS, WBSS	DSS, WBSS	DSS, WBSS	DSS, WBSS
12 in. Asbestos-Cement	DSS, WBSS	DSS, WBSS	DSS, WBSS	DSS, WBSS
12 in. PVC (AWWA C900)	DSS, WBSS	DSS, WBSS	DSS, WBSS	DSS, WBSS
16 in. and up Cast-Iron or Ductile-Iron	DWBSS	DWBSS	DWBSS	DWBSS
16 in. and up Asbestos-Cement	DWBSS	DWBSS	DWBSS	DWBSS
16 in. and up PVC (AWWA C900)	DWBSS	DWBSS	DWBSS	DWBSS
DSS – Dual Strap Saddles WBSS – Wide Band Strap Saddles DWBSS – Dual Wide Band Strap Saddles				

- 3.20.3. **Installing Curb Stops.** Set curb stops or angle stops only at the outer end of the service line just ahead of the meter. Secure the opening in the curb stop to prevent unwanted material from entering. Use eighth bend or quarter bend couplings to accomplish close quarter turns in the service line.

In 3/4 in. and 1 in. services, install a meter coupling or swivel nut meter spud curb stop, ahead of the meter. Also install a straight meter coupling on the outlet end of the meter. Install a new curb stop when the service line is extended.

- 3.20.4. **Sequence of Work.** Open the trench for the proposed service line or prepare the jacking and receiving pits.

Install the corporation stop in a workmanlike manner using the proper equipment.

Install the copper service line and connect it to the corporation stop.

Install the curb stop on the meter end of the service line.

With the curb stop open, and before connecting the service line to the meter, open the corporations stop and flush the service line adequately. Close the curb stop, leaving the corporation stop in the full open position.

Check the service line for apparent leaks. Repair leaks before proceeding.

Connect the service line to the meter and, if necessary, adjust the meter location. Use care to ensure that the inlet side of the meter is connected to the water service line. Momentarily open the curb stop to verify proper registration of the meter.

Backfill the excavations, tamping the backfill material in place to the density of the soil in the adjacent trench walls.

If relocating the meter, relocate the meter box so that it is centered over the meter with the top of the lid flush with the finished grade. When the meter must be located in driveways or sidewalks furnish and install an approved traffic type meter box with a cast-iron lid.

- 3.21. **Cutting and Plugging Water Mains.** Where the plans call for abandoning water mains, adhere to the following general procedure:

After constructing, disinfecting, testing, and placing the replacement main in service, and services are transferred to the replacement main, locate the main to be abandoned, trace it back to the feeder main, and at this point cut and plug it at the tee. Normally, installing a plug, clamp, and a concrete thrust block does this. In cases of 1-1/2 in. or 2 in. corporation cock or tapping sleeve and valve (TS&V) connections, remove

the valve and install a cap or plug at the tee. Ensure the line to be abandoned is not valves off at the nearest valve, nor cut and plugged other than at the supply main.

Adequately plug the ends or openings in abandoned mains or cap them in an approved manner and replace excavation, backfill, and any street surfaces, to the Engineer's satisfaction. Perform this work in accordance with Sections 3.1., "Excavation," and 3.11., "Backfilling."

Remove surface identification, i.e., valve boxes and fire hydrants. Where valve boxes are in improved streets (other than shell), pouring valve boxes full of concrete with the cap permanently removed is permitted.

Do not remove plugs during the months of peak water demands, June, July, and August, unless otherwise approved

- 3.22. **Service Lines of Public Utilities.** Where any pipe or conduit of a public utility corporation crosses the water main trench, support such pipe or conduit in a manner satisfactory to the Engineer.

If the Contractor considers it necessary for a utility company to relocate their utility lines or other improvements, notify the Engineer in advance.

If the Engineer considers it imperative to make the change, the Engineer will make the necessary arrangements with the utility company.

- 3.23. **Relocating Meter Vaults.** Salvage existing valves, meters, and strainers from inside the vault and return them to the Utility Owner, or as designated on the plans.

Install pipe, valves, service lines, and other appurtenances in accordance with the sections of this specification or as directed.

In general, install the type of meter vault shown on the plans or as approved.

- 3.23.1. **Precast Concrete Vault.** Construct and furnish the precast concrete vault as shown on the plans.

Set the precast concrete vault level on a minimum 3 in. bed of sand in an excavation and bring it to grade. Then install piping and backfill with sand around the vault.

- 3.23.2. **Cast-in-Place Concrete Vault.** Construct the cast-in-place concrete vault as shown on the plans. Key the walls to the floor slab and form to the dimensions shown on the plans. Provide a minimum wall thickness of 4 in. Cast the walls monolithically. One cold joint is allowed when the vault depth exceeds 12 ft. Set the frame for the cover while the concrete is still green.

- 3.23.3. **Frame and Cover.** Construct the frame and cover as shown on the plans.

In grass areas, set the frame and cover 2 in. to 3 in. above the natural ground or finished grade and parallel to it (the maximum allowable angle from horizontal is 20°). Slope the backfill away from the meter.

In sidewalk areas, set the frame and cover 1/2 in. to 1 in. above the adjacent concrete and parallel to it. Slope the replacement concrete away from the meter to meet the adjacent concrete.

- 3.23.4. **Inspections.** The following inspections will be made jointly by the Engineer and representatives of the Utility Owner:

- Site Location Inspection - to obtain the required approval of proposed meter location before commencing work.
- Final Inspection – conducted after the backfill is in place, the cover is installed, the cleanup is completed, and the surface is restored.

3.24. **Adjusting Existing Surface Structures.**

- 3.24.1. **Valve Boxes.** Salvage and reuse the valve box. Remove and replace the 6 in. ductile-iron riser pipe with a suitable length for the depth of cover required to establish the adjusted elevation to accommodate the actual finished grade.

Reinstall the valve box and riser piping plumbed in a vertical position. Provide a minimum of 6 in. telescoping freeboard space between the riser pipe top butt end and the interior contact flange of the valve box, for vertical movement damping.

After setting, aligning, and adjusting the valve box so that the top lid is level with the final grade, place a 24 in. by 24 in. by 8 in. thick concrete block around the valve box. Center the valve box horizontally within the concrete box.

- 3.24.2. **Meter Boxes.** Salvage and reuse meter boxes when possible. Reinstall them in conformance with the manufacturer's recommendations. Repair any damage sustained by the meter box during relocation or service transfer, at no expense to the Department.

If the existing meter box requires replacement, the Contractor may obtain a new box from the Utility Owner by providing adequate documentation of the existing and proposed locations.

- 3.24.3. **Meter Vaults.** Adjust meter vaults in conformance with the details shown on the plans. Salvage and reuse access covers.

- 3.25. **Relocating Water Meters and Boxes.** Salvage, clean, inspect, and install existing curb stops, meters, unions, and meter boxes at the new locations in conformance with specifications in this section. When the meter and box is relocated, move it the minimum distance to enable access for new connections. Repair any damage sustained by the meter box during relocation or service transfer, at no expense to the Department.

If unable to salvage the existing boxes, the Contractor may obtain new boxes from the Utility Owner by providing proper documentation of the existing and proposed locations of the meter.

When approved, the Contractor may relocate meter boxes located adjacent to existing pavement, if this operation facilitates construction or decreases the costs. Obtain written approval of the Engineer and perform this work, including excavation, piping, meter box relocation, removal and replacement of paving, etc., at no cost to the Department.

- 3.26. **Installing Split Casing.** Notify the Utility Owner at least 48 hr. in advance of any work planned involving existing water lines. Do not, at any one time, expose more than 20 ft. of water lines to be encased.

Place 6 in. x 6 in. x 1-1/4 in. neoprene pads between the split casing sections and the top and bottom of the water lines spacing them at approximately 6 ft. or as directed.

Ensure the completed and shaped trench to receive the casing is of wide enough to provide free working space for satisfactorily installing the casing and backfilling under and around the casing.

Hold the split casing in place for welding by using hinges, coupling bands, or any other acceptable method.

Use a casing diameter not less than the outside dimension of the pipe at its longest dimension plus 4 in.

Perform welds conforming to the requirements of AWWA Standard C 206. Provide welds capable of developing the full strength of the pipe throughout the joint and casing split.

Seal the ends of the encasement pipe with casing and seals in accordance with Section 2.2.1., "Steel Carrier Pipe," to prevent the entrance of the excessive ground water.

3.27. **Modifications for Cathodic Protection.**

3.27.1. **General.** Provide cathodic protection systems as shown on the plans.

References to steel pipe apply to tape-coated welded steel pipe. If damage occurs to the pipe coatings during the welding process, refurbish the affected area to its original condition.

3.27.2. **Bonded Joints.** Where rubber gasket bell and spigots are provided, provide for bonded joints by either welding a strap or clip between the bell and the spigot of each joint, or by providing a Thermite-welded cable between the bell and the spigot of each joint. Provide pipes, whether installed in a tunnel or open cut, with bonded joints, except where providing insulating flanges. Where welding joints for thrust restraint, no additional bonding is required.

Bonding Strap or Clip: Provide a strap or clip for bonding the bell to the spigot, that is free of foreign material that could increase the contact resistance between the wire and the strap or clip.

Unless otherwise noted, provide insulation kits at connections to the existing water system, at locations to isolate one type of cathodic system from another type, between the water main and extra piping, or as shown on the plans.

3.28. **Removing and Salvaging Fire Hydrants and Water Meters.** Deliver removed and salvaged fire hydrants and water meters to the Utility Owner at the location shown on the plans, or as directed.

3.29. **Installing the Nonmetallic Pipe Detection System.** Install the nonmetallic pipe detection system concurrently with placing the proposed pipe. Install as specified by the manufacturer and as approved.

3.30. **Removing Water Mains and Removing Water Mains with Casing.** Remove water mains and water mains with casing in accordance with Item 100, or as shown on the plans. This includes removing and disposing of pipe and appurtenances as shown on the plans or as directed. Perform related excavation and backfilling, as required, at no additional cost the Department.

3.31. **Adjusting Manholes.** Perform work in accordance with Item 465. Excavate and backfill in accordance with Item 400. Carefully remove and temporarily store as directed, manhole and inlet rings, covers, plates, and grates to be reused. Clean mortar and grease from the contact areas of reused items. Dispose of unused removed material as directed. Use construction methods described in Sections 479.3.1, "Lowering the Top of a Manhole or Inlet," and 479.3.2, "Raising the Top of a Manhole or Inlet," unless otherwise shown on the plans.

3.31.1. **Lowering the Top of a Manhole or Inlet.** Remove a sufficient depth of brick courses or concrete to permit reconstruction on a batter not exceeding 1 in. horizontal to 2 in. vertical. Where brickwork is present, clean the mortar from the top course of brick. Rebuild the manhole or inlet to the original top dimensions or to the dimensions shown in the plans. Install the manhole or inlet ring and the cover, plate, or grate to conform to the proposed new surface contour.

3.31.2. **Raising the Top of a Manhole or Inlet.** Clean the top surface of brick or concrete. Construct to the proper new elevation using new brick, brick salvaged from other manholes or inlets, prefabricated metal extension rings, concrete rings, or Class A concrete. Install the manhole or inlet ring and the cover, plate, or grate to conform to the proposed new surface contour. Install prefabricated extension rings in accordance with manufacturer's instructions.

4. **MEASUREMENT**

4.1. **Water Main Pipe and Steel Casing.** Measured by the foot, of the various sizes and types specified. Water mains and casing will be measured along the axis of the pipe and no deductions will be made for valves or fittings. Reducers will be classed as pipe of the size of the larger end.

Unless otherwise shown on the plans, Fire Hydrant Branches (Leads) will be measured by the foot, of the various types and installation methods specified, along the axis of each branch (lead) from the hydrant to the end of the branch (lead). No deductions will be made for valves or fittings.

- 4.2. **Split Steel Casing.** Measured by the foot, of the various sizes shown on the plans.
- 4.3. **Fiberglass Reinforced Plastic (FRP) Pipe for Casing.** Measured by the foot, of the various sizes shown on the plans.
- 4.4. **Jacking, Tunneling, Boring, or Augering.** Jacking, Tunneling, Boring, or Augering for water mains and steel casing will be measured by the foot, of the sizes, types, and wall thickness (applicable only for casing) specified.

Jacking, Tunneling, Boring, or Augering for fire hydrant branches (leads) will be measured by the foot, of the various types specified.
- 4.5. **New Copper Service Lines.** Measured by each service line installed.

Short Side service line refers to service connections made to meters located on the same side of the street as the supply main is located. Long Side service line refers to service connections made to meters located on the opposite side of the street from the supply main, or from the center of the street, where the supply main is located in the center of the street.
- 4.6. **Gate Valves, Tapping Sleeves and Valves, and Butterfly Valves.** Measured by each assembly installed, of the various sizes specified, except that gate valves 20 in. in diameter and smaller, are subsidiary to the water lines.
- 4.7. **Fire Hydrants.** Measured by each assembly installed, including a 6-in. gate valve and box, regardless of depth. It is the Contractor's responsibility to install the fire hydrant assembly such that it meets the standard installation requirements of this specification and the manufacturer's specifications.

Fire Hydrant Branches (Leads) will be measured as indicated in Sections 4.1., "Water Main Pipe and Steel Casing" and 4.4., "Jacking, Tunneling, Boring, or Augering."
- 4.8. **Meters and Vaults.** Measured by each assembly constructed.
- 4.9. **Air Release and Vacuum Relief Valves.** Measured by each assembly, of the various sizes, with the valve box installed.
- 4.10. **Pressure Reducing Stations.** Measured by the lump sum unit constructed.
- 4.11. **Blow Off Valves.** Measured by each assembly, of the various sizes and types, with the valve box installed.
- 4.12. **Removing Fire Hydrants.** Measured by each assembly removed and disposed of properly.
- 4.13. **Removing Water Valves and Boxes.** Measured by each assembly removed and disposed of properly.
- 4.14. **Removing and Relocating Meters and Boxes.** Measured by each assembly removed, cleaned, and installed at the new location.
- 4.15. **Removing Meters and Vaults.** Measured by each assembly removed and disposed of properly.
- 4.16. **Removing and Salvaging Water Meters.** Measured by each assembly removed and salvaged.
- 4.17. **Removing and Salvaging Fire Hydrants.** Measured by each assembly removed and salvaged.

- 4.18. **Removing and Relocating Water Meters and Meter Vaults.** Measured by each assembly removed and relocated.
- 4.19. **Adjusting Meter Vaults.** Measured by each assembly adjusted.
- 4.20. **Adjusting Meter Boxes.** Measured by each assembly adjusted.
- 4.21. **Adjust or Relocate Water Meter.** Measured by each assembly adjusted or relocated.
- 4.22. **Lowering Water Mains.** Measured by the foot, of the sizes and types of pipe lowered.
- 4.23. **Cutting and Plugging Water Mains.** Measured by each location a water main is cut and plugged, of the sizes indicated.
- 4.24. **Removing Pressure Reducing Stations.** Measured by each complete pressure reducing station removed.
- 4.25. **Wet Connections.** Measured by each connection, of the sizes specified.
- 4.26. **Extra Hand Excavation or Extra Machine Excavation.** Measured by the cubic yard in its original position. Excavation performed by manual labor at the locations specifically designated by the Engineer, and which is not included under or subsidiary to other bid items contained in this specification, is considered Extra Hand Excavation or Extra Machine Excavation.
- 4.27. **Adjusting Manholes.** Adjusted manholes will be measured as each manhole adjusted.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit prices bid for the items of work described below. These prices are full compensation for furnishing, hauling, placing, and installing the materials; for inspecting and testing; and for other materials, labor, equipment, tools, and incidentals.

- 5.1. **Water Main Pipe and Steel Casing.** Payment for water main pipe, and steel casing will be made at the unit prices bid for "Water Main Pipe (Cast-Iron)," "Water Main Pipe (Steel)," "Water Main Pipe (Ductile Iron)," "Water Main Pipe (Copper)," "Water Main Pipe (Polyvinyl Chloride)(PVC)," and "Casing (Steel)," of the various sizes and types specified, installed by the open-cut method.

Unless otherwise shown on the plans or specifications, excavating, disposing of unsuitable excavated material, backfilling, and the material for backfill, for the complete installation of the water main system, are subsidiary to this bid Item.
- 5.2. **Split Steel Casing.** Payment for split steel casing will be made at the unit price bid for "Split Steel Casing," of the various sizes specified, installed by the open cut method.
- 5.3. **Fiberglass Reinforced Plastic (FRP) Pipe for Casing.** Payment for Fiberglass Reinforced Plastic (FRP) Pipe for Casing will be made at the unit price bid for "Fiberglass Reinforced Plastic (FRP) Pipe for Casing" of the various sizes specified.
- 5.4. **Jacking, Tunneling, Boring, or Augering.** Payment for jacking, tunneling, boring, or augering water main will be made at the unit price bid for "Jacking, Tunneling, Boring, or Augering (Water Main)," of the sizes and types specified. This price includes furnishing the pipe.

Payment for jacking, tunneling, boring, or augering fire hydrant branches (leads) will be made at the unit price bid for "Jacking, Tunneling, Boring, or Augering Fire Hydrant Branch (Lead)(6 in.)," of the types and installation method specified. This price includes furnishing the pipe.

Payment for jacking, tunneling, boring, or augering steel casing will be made at the unit price bid for "Jacking, Tunneling, Boring, or Augering Casing (Steel)," of the sizes, types, and wall thickness (applicable only if exceeding minimum thickness, shown in Section 2.2.2, "Steel Casing Pipe") specified. This price includes the casing. Water mains and fire hydrant branches (leads) placed in the casing will be paid for by the appropriate bid item.

Excavating, backfilling, backfill material, and disposing of unsuitable excavated material for jacking, tunneling, boring, or augering pits are subsidiary to these bid items.

- 5.5. **New Copper Service Lines.** Payment for copper service lines will be made at the unit price bid for "Service Line (Short Side 5/8 in. to 1 in.)," "Service Line (Long Side 5/8 in. to 1 in.)," "Service Line (Short Side 1-1/2 in. to 2 in.)" and "Service Line (Long Side 1-1/2 in. to 2 in.)," installed. This price is full compensation for labor, materials, excavation, and backfill required to install the facility, including connection to the customer's service line.
- 5.6. **Gate Valves, Tapping Sleeves and Valves, and Butterfly Valves.** Payment for gate valves (larger than 20 in. in diameter), tapping sleeves and valves, and butterfly valves will be made at the unit price bid for "Gate Valve," "Tapping Sleeve and Valve," and "Butterfly Valve," of the various sizes specified, with the valve box installed.
- 5.7. **Fire Hydrants.** Payment for fire hydrants will be made at the unit price bid for "Fire Hydrant Assembly," including 6 in. gate valve and box, installed regardless of barrel depth.

Payment for fire hydrant branches (leads) will be made at the unit price bid for "Fire Hydrant Branch (Lead) (6 in.)" installed by the open-cut method.

Any adjustment required either in the flow line of the water main or to the barrel length of the fire hydrant is subsidiary to this bid item.
- 5.8. **Meters and Vaults.** Payment for meters and vaults will be made at the unit price bid for "Meter and Vault" constructed.
- 5.9. **Air Release and Vacuum Relief Valves.** Payment for air release and vacuum relief valves will be made at the unit price bid for "Air Release and Vacuum Relief Valve," of the various sizes specified, with the valve box installed.
- 5.10. **Pressure Reducing Stations.** Payment for pressure reducing stations will be made at the unit price bid for "Pressure Reducing Station." This price is full compensation for performing the necessary excavation, backfill, finish grading, constructing the concrete structure, and furnishing and installing station appurtenances addressed under Article 2, "Materials," of this specification.
- 5.11. **Blow Off Valves.** Payment for blow off valves with boxes will be made at the unit price bid for "Blow Off Valve" of the various sizes and types specified, with the valve box installed.
- 5.12. **Removing Fire Hydrants.** Payment for removing fire hydrants will be made at the unit price bid for "Removing Fire Hydrant." This price includes removing valves from the existing location, disposing of the valves, and plugging at the tee. Excavation and backfill required for removing fire hydrants are subsidiary to this bid item.
- 5.13. **Removing Water Valves and Boxes.** Payment for removing water valves and boxes will be made at the unit price bid for "Removing Water Valve and Box." Excavation and backfill required for removing water valves and boxes are subsidiary to this bid item.
- 5.14. **Removing and Relocating Meters and Boxes.** Payment for removing and relocating meters and boxes will be made at the unit price bid for "Removing and Relocating Meter and Box."

- 5.15. **Removing Meters and Vaults.** Payment for removing meters and vaults will be made at the unit price bid for "Removing Meter and Vault." This includes salvaging the meter strainers and valves and delivering them to their owner at the location shown on the plans or as directed.
- 5.16. **Removing and Salvaging Water Meters.** Payment for removing and salvaging water meters will be made at the unit price bid for "Removing and Salvaging Water Meter." This price includes removing salvaged water meters from the existing locations and delivering them to the owner. Excavation, backfill, and finish grading required for removing the water meters are subsidiary to this bid Item.
- 5.17. **Removing and Salvaging Fire Hydrants.** Payment for removing and salvaging fire hydrants will be made at the unit price bid for "Removing and Salvaging Fire Hydrant." The salvaging of fire hydrants will be a cash reimbursement to the owner by the Contractor where the fire hydrants will become the property of the Contractor or the Contractor will deliver the fire hydrants to the Utility Owner at the location shown on the plans. Excavation, backfill, and finish grading required for removing fire hydrants are subsidiary to this bid Item.
- 5.18. **Removing and Relocating Water Meters and Meter Vaults.** Payment for removing and relocating water meters and meter vaults will be made at the unit price for "Removing and Relocating Water Meter and Meter Vault."
- 5.19. **Adjusting Meter Vaults.** Payment for adjusting meter vaults will be made at the unit price bid for "Adjusting Meter Vault." This price is full compensation for furnishing the required materials, including backfill as required, excavation, tools, labor, equipment, and incidentals.
- 5.20. **Adjusting Meter Boxes.** Payment for adjusting meter boxes will be made at the unit price for "Adjusting Meter Box."
- 5.21. **Adjust or Relocate Water Meter.** Payment for adjusting or relocating water meters will be made at the unit price for "Adjusting or Relocating Water Meters." This price is full compensation for adjusting or relocating water meters. Miscellaneous fittings required to complete the work will not be paid for directly, but will be subsidiary to this Item unless otherwise shown on the plans. Water line sterilization and testing of the completed water main system is considered subsidiary to this Item.
- 5.22. **Lowering Water Mains.** Payment for lowering water mains will be made at the unit price bid for "Lowering Water Mains," of the sizes and types of pipe lowered. This price is full compensation for lowering and adjusting pipes, as well as any connected valves, boxes, and service lines. Excavation and backfill required for lowering water mains are subsidiary to this bid Item.
- 5.23. **Cutting and Plugging Water Mains.** Payment for cutting and plugging water mains will be made at the unit price bid for "Cut and Plug Water Main," of the sizes indicated. This price is full compensation for performing excavation, backfill, finish grading, and other incidental items required to abandon or cut and plug the water main as set forth this specification. Where grout is required, as shown on the plans, it is subsidiary to this bid Item.
- 5.24. **Removing Pressure Reducing Stations.** Payment for removing pressure reducing stations will be made at the unit price bid for "Removing Pressure Reducing Station." This price is full compensation for performing the necessary excavation, backfill, finish grading, pipe removal, structure removal, and for tools, equipment, and incidentals.
- 5.25. **Wet Connections.** Payment for wet connections will be made at the unit price bid for "Wet Connections," of the sizes specified.
- 5.26. **Extra Hand Excavation or Extra Machine Excavation.** Payment for extra hand excavation or extra machine excavation will be made at the unit price bid for "Extra Hand Excavation" or "Extra Machine Excavation." This price is full compensation for labor, hand tools, machines, dewatering, and handling and properly disposing of any excess excavated material not suitable for bedding or backfill for this project.

- 5.27. **Adjusting Manholes.** The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Water Main (Adj Exist Manhole)." This price is full compensation for replacement of Air Release / Vacuum Release Valve and installation of the Standard Bollards as shown on the plans; for materials including backfill as required, and for excavation, tools, equipment, labor, and incidentals.

Trench excavation protection or temporary special shoring for trenches greater than 5 ft. in depth, or sloping the sides of these trenches to preclude collapse, will be measured and paid for as required by Item 402, "Trench Excavation Protection," or Item 403, "Temporary Special Shoring."

Furnishing and placing bedding material is subsidiary to the various bid items.

Providing fittings, including necessary concrete thrust blocking, pipe clamps, nipples, pipe coatings, and lubricants, etc. is subsidiary to the water mains in which they are installed.

In addition, providing fittings required due to plan changes or alterations in line and grade, is subsidiary to the water mains in which they are installed.

Furnishing and installing taps, risers, jumpers, blind flanges, cast-iron sleeves, plugs, reducers etc., as required to disinfect and pressure test the new mains is subsidiary to the various bid items. In addition, necessary excavation and backfill, site grading, and maintenance until completion of pressure testing are subsidiary to the various bid items.

Unless otherwise shown on the plans, the work performed and materials furnished to support the pipes or conduits of public utilities are subsidiary to the various bid items.

Furnishing and installing the nonmetallic pipe detection system, as well as the labor and materials necessary for the system, is subsidiary to the various bid items. In addition, ensure that the detection system is complete, operational, and satisfactory to the Utility Owner.

Adjusting valve boxes is subsidiary to the various bid items.

Special Specification 7300

Water Main Relocation



1. DESCRIPTION

Furnish, install, or replace water pipe, water valves, water meters and boxes, water service connections, fire hydrant assemblies, pipe fittings, encasement pipes for water lines, adjust wastewater manhole and supporting materials in conformance with the North Central Texas Council of Governments (NCTCOG) and details shown on the plans. All work must be completed in conformance with the NCTCOG technical specifications unless otherwise noted on the plans authorizing in writing by the Engineer.

2. MATERIALS

Furnish all materials in conformance with the requirements set forth by the NCTCOG Standard Specifications unless otherwise noted on the plans. Materials must meet the "Buy America" requirements set forth by the Department and the NCTCOG. See Article 8, "Measurement," Table 1, for a summary of materials required.

3. PERMITS, TESTING, AND INSPECTION

- 3.1 **Permits.** Acquire all necessary permits from the City of Wylie to perform the work. Contact the following as needed:

- City of Wylie (469) 797-9858,
- North Texas Municipal Water Department (469) 626-4569, and
- North Central Texas Council of Governments (817) 640-3300.

- 3.2 **Testing.** Provide testing for water improvements in conformance to the NCTCOG Item 506, "Open Cut – Water Conduit Installation" or as directed. In general, for water mains, perform the following tests:

- hydrostatic test,
- poly pigging, and
- sterilization test.

Initial testing and required retesting of all materials, construction items, or products incorporated in the work will be performed at the expense of the Contractor by a laboratory approved by the Owner.

- 3.3 **Inspection.** All water mains and their appurtenances will be inspected by a representative of the City of Wylie. These representatives' decision of acceptability of the installation will be final.

4. CONSTRUCTION

- Perform work in a manner consistent with the construction documents, NCTCOG standard details and specifications, and the Department standard details and specifications listed below (first having highest priority):

- Contract Drawings;
- North Central Texas Council of Governments (NCTCOG) Details, Specifications, and Special Provisions; and
- Department Details, Specifications and Special Provisions.
- A copy of the "Public Works Construction Standards" (Standard Specifications for Public Works Construction-North Central Texas Governments- Fifth Edition-2017) may be obtained from the

NCTCOG 616 Six Flags Drive, Arlington, TX 76006 or ordered online at
<http://store2.nctcog.org/NCTCOG/product/ENV101.html>.

5. WORKMANSHIP, WARRANTIES, AND GUARANTEES

Unless otherwise expressly provided in the Contract drawings or specifications, perform the work in conformance with the best modern practice with materials and workmanship of the highest quality and suitable for their purpose. The Owner will judge and determine compliance with these requirements.

Promptly correct or replace all work rejected by the Owner as defective or as failing to conform to the Contract documents whether observed before or after substantial completion and whether or not fabricated, installed or completed. The Contractor will bear all costs of correcting such rejected work, including costs incurred for additional services made necessary thereby.

If within two years after final acceptance of the work by the Owner, as evidenced by the final certificate of acceptance or within such longer or shorter period of time as may be prescribed by law or by the terms of any other applicable special warranty on designated equipment or portions of work as required by the Contract documents, any of the work is found to be defective or not in conformance with the Contract documents, the Contractor must correct it promptly after receipt of a written notice from the Owner to do so. This obligation will survive termination of the Contract. The Owner will give such notice promptly after discovery of the condition.

Remove all portions of the work from the site which are defective or nonconforming and which have not been corrected unless removal is waived in writing by the Owner.

All subcontractors', manufactures' and suppliers' warranties and guarantees, express or implied, respecting any part of the work and any materials used therein, will be obtained and enforced for the benefit of the Owner without the necessity of separate transfer or assignment thereof, provided that if directed by the Engineer, the Contractor will assign such warranties and guarantees in writing to the Owner.

Any work repaired or replaced, pursuant to this section, will be subject to the provisions of this section to the same extent as work originally performed.

The rights and remedies of the Owner provided in this section are in addition to, and do not limit, any rights or remedies afforded to the Owner by law or any other provision of the Contract documents, or in any way limit the Owner's right to recovery of damage due to default under the Contract.

6. PROTECTION OF PERSONS AND PROPERTY

If the Contractor causes damage to the work or property of any separate Contractor at the site, or if any claims arise out of the Contractor's work, the Contractor will promptly attempt to settle with such other Contractor by agreement or agree to otherwise resolve the dispute by arbitration or at law. If a separate contractor causes damage to the work or property of the Contractor or the performance of work by a separate contractor at the site give rise to any other claim, the Contractor will not institute any action, legal or equitable, against Engineer or permit any action against any of them to be maintained and continued in its name or for its benefit in any court or before any arbiter which seeks to impose liability on or to recover damages from Engineer on account of any such damage or claim.

Work of any nature will not begin until trench safety plans are submitted and approved. The total contract time includes the preparation and approval of these documents. Submit these documents expeditiously.

7. EXISTING UTILITIES AND SERVICE LINES

Protect all existing utilities and service lines crossed or exposed by the construction operations. Where Construction operations cut, break, or damage existing utilities or service lines, t replace the utilities and service lines with the same type of original construction, or better, at your own expense.

If it is necessary to change or move the property of any owner or of a public utility, do not move or interfere with the property until authorized by the Engineer. The right is reserved to the owner of any public utility to enter upon the limits of the project for the purpose of making such changes or repairs of their property that may be made necessary by the performance of this contract.

8. MEASUREMENT

The necessary items required to construct the Water Main Relocation as described in the contract documents will be measured as follows.

Table 1

Pay Items

Item Code	Description Code	Bid Item Description	Unit
7300	6001	SAWCUT, REMOVE, & DISPOSE ASPHALT PAV	SY
7300	6002	SAWCUT, REMOVE CONC PAV, DRVWY & SW	SY
7300	6003	REMOVE & DISPOSE GRAVEL DRIVE	SY
7300	6004	FIRE HYDRANT REMOVE, SALVAGE & TRANSP	EA
7300	6005	REMOVE & DISPOSE WATER VALVE	EA
7300	6006	ABAND 2"WL W FLWABL BKFIL, INCLD SEAL RR	LF
7300	6007	ABAND 8"WL W FLWABL BKFIL, INCLD SEAL RR	LF
7300	6008	SODDING	SY
7300	6009	GRAVEL DRIVE CONSTRUCT	SY
7300	6010	SIDEWALK 4" CLASS 'C' CONSTRUCT	SY
7300	6011	TEMP ASPH PAV CONSTRCT VAR THICK	SY
7300	6012	CONNECT TO EXISTING WATER	EA
7300	6013	6" WL FUR. & INSTALL BY OPEN CUT	LF
7300	6014	8" WL FURNISH & INSTALL BY OPEN CUT	LF
7300	6015	8" WL WITH 14" STEEL CASING BY OPEN CUT	LF
7300	6016	8" WL WITH 14" STEEL CASING BY BORE	LF
7300	6017	DUCTILE IRON FITTINGS FURNISH & INSTALL	TON
7300	6018	FURNISH AND INSTALL 6" VALVE	EA

7300	6019	FURNISH AND INSTALL 8" VALVE	EA
7300	6020	FURNISH AND INSTALL 2" BLOW OFF VALVE	EA
7300	6021	WATR SERV 1" SHRT SIDE, NEW METR & CONCT	EA
7300	6022	WATR SERV 1" LONG SIDE NEW METR & CONNCT	EA
7300	6023	WATR SERV 2" SHRT SIDE NEW METR & CONNCT	EA
7300	6024	FIRE HYD FUR & INSTL INCLUD CONC PAD	EA
7300	6025	WATER LINE TEST	EA
7300	6026	TRENCH SAFETY (FOR WATER)	LF
7300	6027	TRENCH & BORE PIT SAFETY AT RR	LS
7300	6028	PROVIDE TREE PROTECTION, PRIVATE PROPE	EA
7300	6029	WATR SERV 2" LNG SIDE NEW METR & CONNCT	EA

9. PAYMENT

The work performed in accordance this Specification, "Water Main Relocation" will be measured and paid for at the unit price for the various items of work listed under Article 8, "Measurement." The unit price for the various items of work identified under Article 8, "Measurement" will include the cost of excavation, embankment, backfill labor, equipment, inspection, and any other materials necessary for the complete installation in accordance with the construction plans and standard specifications.

G. SPECIAL SPECIFICATIONS (CRRMA)

Special Specification RMA1

**Section 055113; 055213; 061000; 061643; 062200; 066116; 072100;
074113; 076200; 078400; 079200; 081113; 081113; 081423; 083113;
083323; 084000; 084413; 087100; 087113; 088000; 092200; 092216;
092900; 093000; 095100; 096513; 096519; 096813; 097813; 099100;
101110; 101450; 102115; 102600;102813;104413**

Tenant Improvements

SECTION 055113 - METAL PAN STAIRS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Preassembled steel stairs with **concrete-filled** treads.
 - 2. **Steel tube** railings and guards attached to metal stairs.
 - 3. **Steel tube** handrails attached to walls adjacent to metal stairs.
 - 4. Railing gates at the level of exit discharge.

1.3 COORDINATION

- A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written instructions to ensure that shop primers and topcoats are compatible with one another.
- B. Coordinate installation of anchorages for metal stairs, **railings, and guards**.
 - 1. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, **blocking for attachment of wall-mounted handrails**, and items with integral anchors, that are to be embedded in concrete or masonry.
 - 2. Deliver such items to Project site in time for installation.
- C. Coordinate locations of hanger rods and struts with other work so they do not encroach on required stair width and are within fire-resistance-rated stair enclosure.
- D. Schedule installation of railings and guards so wall attachments are made only to completed walls.
 - 1. Do not support railings and guards temporarily by any means that do not satisfy structural performance requirements.

1.4 ACTION SUBMITTALS

- A. Product Data: For metal pan stairs and the following:

1. Abrasive nosings.
2. Shop primer products.
3. Nonslip-aggregate concrete finish.
4. Handrail wall brackets.
5. Grout.

B. Shop Drawings:

1. Include plans, elevations, sections, details, and attachments to other work.
2. Indicate sizes of metal sections, thickness of metals, profiles, holes, and field joints.
3. Include plan at each level.
4. Indicate locations of anchors, weld plates, and blocking for attachment of wall-mounted handrails.

C. Samples for Verification: For each type and finish of tread.

D. Delegated-Design Submittal: For stairs, **railings and guards**, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For professional engineer's experience with providing delegated-design engineering services of the kind indicated, including documentation that engineer is licensed in the state of Texas in which Project is located.
- B. Welding certificates.
- C. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers, certifying that shop primers are compatible with topcoats.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Fabricator of products.
- B. Welding Qualifications: Qualify procedures and personnel according to the following:
1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 2. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store materials to permit easy access for inspection and identification.

1. Keep steel members off ground and spaced by using pallets, dunnage, or other supports and spacers.
2. Protect steel members and packaged materials from corrosion and deterioration.
3. Do not store materials on structure in a manner that might cause distortion, damage, or overload to members or supporting structures.
 - a. Repair or replace damaged materials or structures as directed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design stairs, **railings and guards**, including attachment to building construction.
- B. Structural Performance of Stairs: Metal stairs shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
 1. Uniform Load: 100 lbf/sq. ft. (4.79 kN/sq. m).
 2. Concentrated Load: 300 lbf (1.33 kN) applied on an area of 4 sq. in. (2580 sq. mm).
 3. Uniform and concentrated loads need not be assumed to act concurrently.
 4. Stair Framing: Capable of withstanding stresses resulting from railing and guard loads in addition to loads specified above.
 5. Limit deflection of treads, platforms, and framing members to L/360 or 1/4 inch (6.4 mm), whichever is less.
- C. Structural Performance of Railings and Guards: Railings and guards, including attachment to building construction, shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
 1. Handrails and Top Rails of Guards:
 - a. Uniform load of 50 lbf/ft. (0.73 kN/m) applied in any direction.
 - b. Concentrated load of 200 lbf (0.89 kN) applied in any direction.
 - c. Uniform and concentrated loads need not be assumed to act concurrently.
 2. Infill of Guards:
 - a. Concentrated load of 50 lbf (0.22 kN) applied horizontally on an area of 1 sq. ft. (0.093 sq. m).
 - b. Infill load and other loads need not be assumed to act concurrently.
 3. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 - a. Temperature Change: **120 deg F (67 deg C), ambient; material surfaces.**

- D. Seismic Performance of Stairs: Metal stairs shall withstand the effects of earthquake motions determined according to **ASCE/SEI 7**.

2.2 METALS

- A. Metal Surfaces: Provide materials with smooth, flat surfaces unless otherwise indicated. For components exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.
- B. Steel Plates, Shapes, and Bars: ASTM A36/A36M.
- C. Steel Tubing for Railings and Guards: ASTM A500/A500M (cold formed) or ASTM A513/A513M.
1. Provide galvanized finish for exterior installations and where indicated.
- D. Steel Pipe for Railings and Guards: ASTM A53/A53M, Type F or Type S, Grade A, Standard Weight (Schedule 40), unless another grade and weight are required by structural loads.
1. Provide galvanized finish for exterior installations and where indicated.
- E. Uncoated, Cold-Rolled Steel Sheet: ASTM A1008/A1008M, either commercial steel, Type B, or structural steel, Grade 25 (Grade 170), unless another grade is required by design loads.
- F. Uncoated, Hot-Rolled Steel Sheet: ASTM A1011/A1011M, either commercial steel, Type B, or structural steel, Grade 30 (Grade 205), unless another grade is required by design loads.
- G. Galvanized-Steel Sheet: ASTM A653/A653M, G90 (Z275) coating, either commercial steel, Type B, or structural steel, Grade 33 (Grade 230), unless another grade is required by design loads.

2.3 ABRASIVE NOSINGS

- A. Cast-Metal Units: Cast iron, with an integral abrasive, as-cast finish consisting of aluminum oxide, silicon carbide, or a combination of both. Fabricate units in lengths necessary to accurately fit openings or conditions
1. Configuration: Cross-hatched units, 3 inches (75 mm) wide without lip.
2.
3. Provide ribbed units, with abrasive filler strips projecting 1/16 inch (1.5 mm) above aluminum extrusion.
4. Provide solid-abrasive units without ribs.
5. Nosings: Square-back units, 3 inches (75 mm) wide, without lip.
6. Nosings: Two-piece units, 3 inches (75 mm) wide, with subchannel for casting into concrete.

- B. Provide anchors for embedding units in concrete, either integral or applied to units, as standard with manufacturer.
- C. Apply bituminous paint to concealed surfaces of cast-metal units set into concrete.
- D. Apply clear lacquer to concealed surfaces of extruded units set into concrete.

2.4 FASTENERS

- A. General: Provide **zinc-plated fasteners with coating complying with ASTM B633 or ASTM F1941/F1941M, Class Fe/Zn 5** where built into exterior walls.
 - 1. Select fasteners for type, grade, and class required.
- B. Fasteners for Anchoring Railings and Guards to Other Construction: Select fasteners of type, grade, and class required to produce connections suitable for anchoring railings and guards to other types of construction indicated **and capable of withstanding design loads**].
- C. Bolts and Nuts: Regular hexagon-head bolts, ASTM A307, Grade A; with hex nuts, ASTM A563 (ASTM A563M); and, where indicated, flat washers.
- D. Anchor Bolts: ASTM F1554, Grade 36, of dimensions indicated; with nuts, ASTM A563 (ASTM A563M); and, where indicated, flat washers.
 - 1. Provide mechanically deposited or hot-dip, zinc-coated anchor bolts for **exterior stairs stairs indicated to be galvanized**.
- E. Post-Installed Anchors: **Torque-controlled expansion anchors** capable of sustaining, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing according to ASTM E488/E488M, conducted by a qualified independent testing agency.
 - 1. Material for Interior Locations: Carbon-steel components zinc plated to comply with ASTM B633 or ASTM F1941/F1941M, Class Fe/Zn 5, unless otherwise indicated.
 - 2. Material for Exterior Locations and Where Stainless Steel Is Indicated: Alloy Group 1 (A1) stainless-steel bolts, ASTM F593, and nuts, ASTM F594 (ASTM F836M).

2.5 MISCELLANEOUS MATERIALS

- A. Handrail Wall Brackets: **Cast nickel-silver**, center of rail 2-1/2 inches (63.5 mm) from face of wall.
- B. Welding Electrodes: Comply with AWS requirements.
- C. Shop Primers: Provide primers that comply with **Interior Painting**.

- D. Universal Shop Primer: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with MPI#79 and compatible with topcoat.
 - 1. Use primer containing pigments that make it easily distinguishable from zinc-rich primer.
- E. Zinc-Rich Primer: Comply with SSPC-Paint 20, **Type I-A**, and compatible with topcoat.
- F. Shop Primer for Galvanized Steel: Primer formulated for exterior use over zinc-coated metal and compatible with finish system indicated.
- G. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 ASTM A780/A780M and compatible with paints specified to be used over it.
- H. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D1187/D1187M.
- I. Nonmetallic, Shrinkage-Resistant Grout: ASTM C1107/C1107M, factory-packaged, nonmetallic aggregate grout; recommended by manufacturer for exterior use; noncorrosive and nonstaining; mixed with water to consistency suitable for application and a 30-minute working time.

2.6 FABRICATION, GENERAL

- A. Provide complete stair assemblies, including metal framing, hangers, struts, **railings and guards**, clips, brackets, bearing plates, and other components necessary to support and anchor stairs and platforms on supporting structure.
 - 1. Join components by welding unless otherwise indicated.
 - 2. Use connections that maintain structural value of joined pieces.
- B. Assemble stairs, **railings, and guards** in shop to greatest extent possible.
 - 1. Disassemble units only as necessary for shipping and handling limitations.
 - 2. Clearly mark units for reassembly and coordinated installation.
- C. Cut, drill, and punch metals cleanly and accurately.
 - 1. Remove burrs and ease edges to a radius of approximately 1/32 inch (1 mm) unless otherwise indicated.
 - 2. Remove sharp or rough areas on exposed surfaces.
- D. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
- E. Form exposed work with accurate angles and surfaces and straight edges.
- F. Weld connections to comply with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 2. Obtain fusion without undercut or overlap.
 3. Remove welding flux immediately.
 4. Weld exposed corners and seams continuously unless otherwise indicated.
 5. At exposed connections, finish exposed welds to comply with NOMMA's "Voluntary Joint Finish Standards" for **Finish #2 - Completely sanded joint with some undercutting and pinholes okay removed.**
- G. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible.
1. Where exposed fasteners are required, use Phillips flat-head (countersunk) screws or bolts unless otherwise indicated.
 2. Locate joints where least conspicuous.
 3. Fabricate joints that will be exposed to weather in a manner to exclude water.
 4. Provide weep holes where water may accumulate internally.

2.7 FABRICATION OF STEEL-FRAMED STAIRS

- A. NAAMM Stair Standard: Comply with NAAMM AMP 510, "Metal Stairs Manual," for **Commercial** Class, unless more stringent requirements are indicated.
- B. Stair Framing:
1. Fabricate stringers **of steel plates.**
 - a. Stringer Size: **As required to comply with "Performance Requirements" Article As indicated on Drawings.**
 - b. Provide closures for exposed ends of channel and rectangular tube stringers.
 - c. Finish: **Galvanized.**
 2. Construct platforms of steel **plate** headers and miscellaneous framing members **as required to comply with "Performance Requirements".**
 - a. Provide closures for exposed ends of channel and rectangular tube framing.
 - b. Finish: **Galvanized.**
 3. **Bolt** stringers to headers; **bolt** framing members to stringers and headers. **Fabricate and join so bolts are not exposed on finished surfaces.**
 - a. Locate hanger rods and struts where they do not encroach on required stair width and are within the fire-resistance-rated stair enclosure.
- C. Metal Pan Stairs: Form risers, subread pans, and subplatforms to configurations shown from steel sheet of thickness needed to comply with performance requirements, but not less than 0.067 inch (1.7 mm).

1. Fabricate treads and landing subplatforms of exterior stairs so finished walking surfaces slope to drain.
 2. Steel Sheet: Uncoated, **cold**-rolled steel sheet **unless indicated**.
 3. Steel Sheet: Galvanized-steel sheet, **where indicated**.
 4. Directly weld metal pans to stringers; locate welds on top of subtreads where they will be concealed by concrete fill. Do not weld risers to stringers.
 5. Attach risers and subtreads to stringers with brackets made of steel angles or bars. Weld brackets to stringers and attach metal pans to brackets by welding, riveting, or bolting.
 6. Shape metal pans to include nosing integral with riser.
 7. Attach abrasive nosings to risers.
 8. At Contractor's option, provide stair assemblies with metal pan subtreads filled with reinforced concrete during fabrication.
 9. Provide epoxy-resin-filled treads, reinforced with glass fibers, with non-slip-concrete aggregate finish to tread surface.
 10. Provide subplatforms of configuration indicated or, if not indicated, the same as subtreads. Weld subplatforms to platform framing.
 - a. Smooth Soffit Construction: Construct subplatforms with flat metal under surfaces to produce smooth soffits.
- D. Abrasive-Coating-Finished, Formed-Metal Stairs: Form risers, treads, and platforms to configurations shown from steel sheet of thickness needed to comply with performance requirements, but not less than 0.097 inch (2.5 mm).
1. Steel Sheet: Uncoated, hot-rolled steel sheet unless otherwise indicated.
 2. Directly weld risers and treads to stringers; locate welds on underside of stairs.
 3. Provide platforms of configuration indicated or, if not indicated, the same as treads. Weld platforms to platform framing.
 4. Finish tread and platform surfaces with manufacturer's standard epoxy-bonded abrasive finish.

2.8 FABRICATION OF STAIR RAILINGS AND GUARDS

- A. Comply with applicable requirements in **Section 055213 "Pipe and Tube Railings"**.
- B. Fabricate railings and guards to comply with requirements indicated for design, dimensions, details, finish, and member sizes, including wall thickness of member, post spacings, wall bracket spacing, and anchorage, but not less than that needed to withstand indicated loads.
1. Rails and Posts: **1-1/2-inch- (38-mm-) square** top and bottom rails and 1-1/2-inch- (38-mm-) square posts.
 2. Picket Infill: **3/4-inch- (19-mm-) square** pickets spaced to prohibit the passage of a 4-inch (100-mm) diameter sphere.
 3. Intermediate Rails Infill: **1-5/8-inch- (41-mm-) diameter, 1-inch- (38-mm-) square** intermediate rails spaced less than **12 inches (305 mm) 21 inch (533 mm)** clear.
- C. Welded Connections: Fabricate railings and guards with welded connections.

1. Fabricate connections that are exposed to weather in a manner that excludes water.
 - a. Provide weep holes where water may accumulate internally.
 2. Cope components at connections to provide close fit, or use fittings designed for this purpose.
 3. Weld all around at connections, including at fittings.
 4. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 5. Obtain fusion without undercut or overlap.
 6. Remove flux immediately.
 7. Finish welds to comply with NOMMA's "Voluntary Joint Finish Standards" for **#2 - Completely sanded joint, some undercutting and pinholes are okay** as shown in NAAMM AMP 521.
- D. Form changes in direction of railings and guards as follows:
1. By radius bends of radius indicated **or by inserting prefabricated elbow fittings of radius indicated.**
- E. For changes in direction made by bending, use jigs to produce uniform curvature for each repetitive configuration required. Maintain cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of components.
- F. Close exposed ends of railing and guard members with prefabricated end fittings.
- G. Provide wall returns at ends of wall-mounted handrails unless otherwise indicated.
1. Close ends of returns unless clearance between end of rail and wall is 1/4 inch (6 mm) or less.
- H. Connect posts to stair framing by direct welding unless otherwise indicated.
- I. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, end closures, flanges, miscellaneous fittings, and anchors for interconnecting components and for attaching to other work.
1. Furnish inserts and other anchorage devices for connecting to concrete or masonry work.
 2. For galvanized railings and guards, provide galvanized fittings, brackets, fasteners, sleeves, and other ferrous-metal components.
 3. For nongalvanized railings and guards, provide nongalvanized ferrous-metal fittings, brackets, fasteners, and sleeves, except galvanize anchors embedded in exterior masonry and concrete construction.
 4. Provide type of bracket **with flange tapped for concealed anchorage to threaded hanger bolt** and that provides 1-1/2-inch (38-mm) clearance from inside face of handrail to finished wall surface.

- J. Fillers: Provide fillers made from steel plate, or other suitably crush-resistant material, where needed to transfer wall bracket loads through wall finishes to structural supports.
 - 1. Size fillers to suit wall finish thicknesses and to produce adequate bearing area to prevent bracket rotation and overstressing of substrate.

2.9 FINISHES

- A. Finish metal stairs after assembly.
- B. Galvanizing: Hot-dip galvanize items as indicated to comply with ASTM A153/A153M for steel and iron hardware and with ASTM A123/A123M for other steel and iron products.
 - 1. Do not quench or apply post-galvanizing treatments that might interfere with paint adhesion.
 - 2. Fill vent and drain holes that are exposed in the finished Work, unless indicated to remain as weep holes, by plugging with zinc solder and filing off smooth.
- C. Preparation for Shop Priming: Prepare uncoated, ferrous-metal surfaces to comply with SSPC-SP 3, "Power Tool Cleaning."
- D. Apply shop primer to uncoated surfaces of metal stair components, except those with galvanized finishes and those to be embedded in concrete or masonry unless otherwise indicated. Comply with SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify elevations of floors, bearing surfaces and locations of bearing plates, and other embedments for compliance with requirements.
 - 1. For wall-mounted railings, verify locations of concealed reinforcement within gypsum board and plaster assemblies.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF METAL PAN STAIRS

- A. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing metal stairs to in-place construction.
 - 1. Include threaded fasteners for concrete and masonry inserts, through-bolts, lag bolts, and other connectors.

- B. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal stairs. Set units accurately in location, alignment, and elevation, measured from established lines and levels and free of rack.
- C. Install metal stairs by welding stair framing to steel structure or to weld plates cast into concrete unless otherwise indicated.
 - 1. Grouted Baseplates: Clean concrete- and masonry-bearing surfaces of bond-reducing materials, and roughen surfaces prior to setting plates.
 - a. Clean bottom surface of plates.
 - b. Set plates for structural members on wedges, shims, or setting nuts.
 - c. Tighten anchor bolts after supported members have been positioned and plumbed.
 - d. Do not remove wedges or shims but, if protruding, cut off flush with edge of plate before packing with grout.
 - e. Promptly pack grout solidly between bearing surfaces and plates so no voids remain.
 - 1) Neatly finish exposed surfaces; protect grout and allow to cure.
 - 2) Comply with manufacturer's written installation instructions for shrinkage-resistant grouts.
- D. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.
- E. Fit exposed connections accurately together to form hairline joints.
 - 1. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations.
 - 2. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.
 - 3. Comply with requirements for welding in "Fabrication, General" Article.
- F. Place and finish concrete fill for treads and platforms to comply with Section 033000 "Cast-in-Place Concrete."
 - 1. Install abrasive nosings with anchors fully embedded in concrete.
 - 2. Center nosings on tread width.
- G. Install precast concrete treads with adhesive supplied by manufacturer.
- H. Install precast terrazzo treads according to manufacturer's written instructions.

3.3 INSTALLATION OF RAILINGS AND GUARDS

- A. Adjust railing and guard systems before anchoring to ensure matching alignment at abutting joints with tight, hairline joints.

1. Space posts at spacing indicated or, if not indicated, as required by design loads.
2. Plumb posts in each direction, within a tolerance of 1/16 inch in 3 feet (2 mm in 1 m).
3. Align rails and guards so variations from level for horizontal members and variations from parallel with rake of stairs for sloping members do not exceed 1/4 inch in 12 feet (6 mm in 3.5 m).
4. Secure posts, rail ends, and guard ends to building construction as follows:
 - a. Anchor posts to steel by **bolting** to steel supporting members.
 - b. Anchor handrail and guard ends to concrete and masonry with steel round flanges welded to rail and guard ends and anchored with post-installed anchors and bolts.

B. Install railing gates level, plumb, and secure for full opening without interference.

1. Attach hardware using tamper-resistant or concealed means.
2. Adjust hardware for smooth operation.

C. Attach handrails to wall with wall brackets.

1. Locate brackets as indicated or, if not indicated, at spacing required to support structural loads.
2. Secure wall brackets to building construction as **required to comply with performance requirements. follows:**
 - a. For steel-framed partitions, use hanger or lag bolts set into **fire-retardant-treated** wood backing between studs. Coordinate with stud installation to locate backing members.
 - b. For steel-framed partitions, use self-tapping screws fastened to steel framing or to concealed steel reinforcements.
 - c. For steel-framed partitions, use toggle bolts installed through flanges of steel framing or through concealed steel reinforcements.

3.4 REPAIR

- A. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
 1. Apply by brush or spray to provide a minimum 2.0-mil (0.05-mm) dry film thickness.
- B. Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in **Section 099000 Painting**.
- C. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A780/A780M.

END OF SECTION 055113

SECTION 055213 - PIPE AND TUBE RAILINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

1. Steel railings.
2. Aluminum railings.
3. Stainless steel railings.

- B. Related Requirements:

1. Section 055113 "Metal Pan Stairs" for steel tube railings associated with metal pan stairs.
- 2.

1.3 COORDINATION

- A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.
- B. Coordinate installation of anchorages for railings. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

1.4 ACTION SUBMITTALS

- A. Product Data:

1. Manufacturer's product lines of mechanically connected railings.
2. Fasteners.
3. Post-installed anchors.
4. Handrail brackets.
5. Shop primer.
6. Intermediate coats and topcoats.

7. Nonshrink, nonmetallic grout.
8. Anchoring cement.
9. Metal finishes.
10. Paint products.

B. Sustainable Design Submittals:

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

D. Samples for Initial Selection: For products involving selection of color, texture, or design.

E. Samples for Verification: For each type of exposed finish required.

1. Sections of each distinctly different linear railing member, including handrails, top rails, posts, and balusters, including finish.
2. Fittings and brackets.
3. Assembled Sample of railing system, made from full-size components, including top rail, post, handrail, and infill. Sample need not be full height.

a. Show method of **connecting and finishing** members at intersections.

F. Delegated-Design Submittal: For railings, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For **delegated-design professional engineer**.

B. Welding certificates.

C. Mill Certificates: Signed by manufacturers of stainless steel products, certifying that products furnished comply with requirements.

D. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers, certifying that shop primers are compatible with topcoats.

E. Product Test Reports: For tests on railings performed by a qualified testing agency, in accordance with ASTM E894 and ASTM E935.

F. Research Reports: For post-installed anchors, from ICC-ES or other qualified testing agency acceptable to authorities having jurisdiction.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel in accordance with the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Protect mechanical finishes on exposed surfaces of railings from damage by applying a strippable, temporary protective covering before shipping.

1.8 FIELD CONDITIONS

- A. Field Measurements: Verify actual locations of walls and other construction contiguous with railings by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design railings, including attachment to building construction.
- B. Structural Performance: Railings, including attachment to building construction, shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
 - 1. Handrails and Top Rails of Guards:
 - a. Uniform load of 50 lbf/ ft. (0.73 kN/m) applied in any direction.
 - b. Concentrated load of 200 lbf (0.89 kN) applied in any direction.
 - c. Uniform and concentrated loads need not be assumed to act concurrently.
 - 2. Infill of Guards:
 - a. Concentrated load of 50 lbf (0.22 kN) applied horizontally on an area of 1 sq. ft. (0.093 sq. m).
 - b. Infill load and other loads need not be assumed to act concurrently.
- C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 - 1. Temperature Change: **120 deg F (67 deg C), ambient;**

2.2 METALS, GENERAL

- A. Metal Surfaces, General: Provide materials with smooth surfaces, without seam marks, roller marks, rolled trade names, stains, discolorations, or blemishes.
- B. Brackets, Flanges, and Anchors: Cast or formed metal of same type of material and finish as supported rails unless otherwise indicated.

1. Provide type of bracket with **flange tapped for concealed anchorage to threaded hanger bolt** and that provides 1-1/2-inch (38-mm) clearance from inside face of handrail to finished wall surface. Steel pipe railings are generally fabricated by local ironworks. If listing manufacturers from Paragraph Builder, consider adding names of local fabricators to list.
- C. Source Limitations: Obtain each type of railing from single source from single manufacturer.
- D. Tubing: **ASTM A500/A500M (cold formed)**.
- E. Pipe: ASTM A53/A53M, Type F or Type S, Grade A, Standard Weight (Schedule 40), unless another grade and weight are required by structural loads.
 1. Provide galvanized finish for exterior installations and where indicated.
- F. Plates, Shapes, and Bars: ASTM A36/A36M.
- G. Cast Iron Fittings: Either gray iron, ASTM A48/A48M, or malleable iron, ASTM A47/A47M, unless otherwise indicated.
 1. Galvanized-Steel Sheet, ASTM A653/A653M, G90 (Z275) coating, commercial steel Type B, **0.064 inch (1.63 mm), with 1/4-inch (6.4-mm) holes 3/8 inch (9.5 mm) o.c. in staggered rows.**

2.3 FASTENERS

- A. Fastener Materials:
 1. Ungalvanized-Steel Railing Components: Plated steel fasteners complying with ASTM F1941 (ASTM F1941M), Class Fe/Zn 5 for zinc coating.
 2. Hot-Dip Galvanized Railing Components: Type 304 stainless steel or hot-dip zinc-coated steel fasteners complying with ASTM A153/A153M or ASTM F2329/F2329M for zinc coating.
 3. Aluminum Railing Components: Type 304 stainless steel fasteners.
 4. Stainless Steel Railing Components: Type 304 stainless steel fasteners.
 5. Finish exposed fasteners to match appearance, including color and texture, of railings.
- B. Fasteners for Anchoring Railings to Other Construction: Select fasteners of type, grade, and class required to produce connections suitable for anchoring railings to other types of construction **and capable of withstanding design loads**.
- C. Fasteners for Interconnecting Railing Components:
 1. Provide concealed fasteners for interconnecting railing components and for attaching them to other work, unless otherwise indicated.

2. Provide concealed fasteners for interconnecting railing components and for attaching them to other work, unless exposed fasteners are unavoidable or are the standard fastening method for railings indicated.
 3. Provide **Phillips** flat-head machine screws for exposed fasteners unless otherwise indicated.
- D. Post-Installed Anchors: Fastener systems with working capacity greater than or equal to the design load, according to an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC193 or **ICC-ES AC308**.
1. Material for Interior Locations: Carbon-steel components zinc-plated to comply with ASTM B633 or ASTM F1941/F1941M, Class Fe/Zn 5, unless otherwise indicated.
 2. Material for Exterior Locations and Where Stainless Steel Is Indicated: Alloy Group 1 (A1) stainless steel bolts, ASTM F593, and nuts, ASTM F594.

2.4 MISCELLANEOUS MATERIALS

- A. Handrail Brackets: Cast nickel-silver, center of handrail **2-1/2 inches (63.5 mm)**. Welding Rods and Bare Electrodes: Select in accordance with AWS specifications for metal alloy welded.
- B. Etching Cleaner for Galvanized Metal: Complying with MPI#25.
- C. Galvanizing Repair Paint: High-zinc-dust-content paint, complying with SSPC-Paint 20 and compatible with paints specified to be used over it.
- D. Shop Primers: Provide primers that comply with **Section 099000 Painting**.
- E. Universal Shop Primer" Paragraph below specifies a typical primer for painted finishes that provides minimum protection to steel.
- F. Universal Shop Primer: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with MPI#79 and compatible with topcoat.
1. Use primer containing pigments that make it easily distinguishable from zinc-rich primer.
- G. Epoxy Zinc-Rich Primer: Complying with MPI#20 and compatible with topcoat.
- H. Shop Primer for Galvanized Steel: Primer formulated for exterior use over zinc-coated metal and compatible with finish paint systems indicated.
- I. Intermediate Coats and Topcoats: Provide products that comply with **Section 099000 Painting**. Epoxy Intermediate Coat: Complying with MPI #77 and compatible with primer and topcoat.
- J. Polyurethane Topcoat: Complying with MPI #72 and compatible with undercoat.

- K. Bituminous Paint: Cold-applied asphalt emulsion, complying with ASTM D1187/D1187M.
- L. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout, complying with ASTM C1107/C1107M. Provide grout specifically recommended by manufacturer for interior and exterior applications.
- M. Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with water at Project site to create pourable anchoring, patching, and grouting compound.
 - 1. Water-Resistant Product: **where indicated on Drawings**, provide formulation that is resistant to erosion from water exposure without needing protection by a sealer or waterproof coating and that is recommended by manufacturer for exterior use.

2.5 FABRICATION

- A. General: Fabricate railings to comply with requirements indicated for design, dimensions, member sizes and spacing, details, finish, and anchorage, **but not less than that required to support structural loads**.
- B. Shop assemble railings to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations.
 - 1. Clearly mark units for reassembly and coordinated installation.
 - 2. Use connections that maintain structural value of joined pieces.
- C. Cut, drill, and punch metals cleanly and accurately.
 - 1. Remove burrs and ease edges to a radius of approximately 1/32 inch (1 mm) unless otherwise indicated.
 - 2. Remove sharp or rough areas on exposed surfaces.
- D. Form work true to line and level with accurate angles and surfaces.
- E. Fabricate connections that are exposed to weather in a manner that excludes water.
 - 1. Provide weep holes where water may accumulate.
 - 2. Locate weep holes in inconspicuous locations.
- F. Cut, reinforce, drill, and tap as indicated to receive finish hardware, screws, and similar items.
- G. Connections: Fabricate railings with **welded** connections unless otherwise indicated.
- H. Welded Connections: Cope components at connections to provide close fit, or use fittings designed for this purpose. Weld all around at connections, including at fittings.

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 2. Obtain fusion without undercut or overlap.
 3. Remove flux immediately.
 4. At exposed connections, finish exposed welds to comply with NOMMA's "Voluntary Joint Finish Standards" for **Finish #1 welds; ornamental quality with no evidence of a welded joint.**
- I. Welded Connections for Aluminum Pipe: Fabricate railings to interconnect members with concealed internal welds that eliminate surface grinding, using manufacturer's standard system of sleeve and socket fittings.
- J. Nonwelded Connections: Connect members with concealed mechanical fasteners and fittings. Fabricate members and fittings to produce flush, smooth, rigid, hairline joints.
1. Fabricate splice joints for field connection, using an epoxy structural adhesive, if this is manufacturer's standard splicing method.
- K. Form changes in direction as follows:
1. As detailed.
 2. **By radius bends of radius indicated or by inserting prefabricated elbow fittings of radius indicated.**
- L. Bend members in jigs to produce uniform curvature for each configuration required. Maintain cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of components.
- M. Close exposed ends of hollow railing members with prefabricated cap and end fittings of same metal and finish as railings.
- N. Provide wall returns at ends of wall-mounted handrails unless otherwise indicated. Close ends of returns unless clearance between end of rail and wall is 1/4 inch (6 mm) or less.
- O. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, flanges, miscellaneous fittings, and anchors to interconnect railing members to other work unless otherwise indicated.
1. At brackets and fittings fastened to plaster or gypsum board partitions, provide crush-resistant fillers or other means to transfer loads through wall finishes to structural supports and prevent bracket or fitting rotation and crushing of substrate.
- P. Provide inserts and other anchorage devices for connecting railings to concrete or masonry work.
1. Fabricate anchorage devices capable of withstanding loads imposed by railings.
 2. Coordinate anchorage devices with supporting structure.

- Q. For railing posts set in concrete, provide stainless steel sleeves not less than 6 inches (150 mm) long with inside dimensions not less than 1/2 inch (13 mm) greater than outside dimensions of post, with metal plate forming bottom closure.
- R. For removable railing posts, fabricate slip-fit sockets from stainless steel tube or pipe whose ID is sized for a close fit with posts; limit movement of post without lateral load, measured at top, to not more than one-fortieth of post height.
 - 1. Provide socket covers designed and fabricated to resist being dislodged.
 - 2. Provide chain with eye, snap hook, and staple across gaps formed by removable railing sections at locations indicated. Fabricate from same metal as railings.
- S. Toe Boards: Where indicated, provide toe boards at railings around openings and at edge of open-sided floors and platforms. Fabricate to dimensions and details indicated.

2.6 STEEL AND IRON FINISHES

- A. Galvanized Railings:
 - 1. Hot-dip galvanize steel railings, including hardware, after fabrication.
 - 2. Comply with ASTM A123/A123M for hot-dip galvanized railings.
 - 3. Comply with ASTM A153/A153M for hot-dip galvanized hardware.
 - 4. Do not quench or apply post-galvanizing treatments that might interfere with paint adhesion.
 - 5. Fill vent and drain holes that are exposed in the finished Work, unless indicated to remain as weep holes, by plugging with zinc solder and filing off smooth.
- B. For galvanized railings, provide hot-dip galvanized fittings, brackets, fasteners, sleeves, and other ferrous components.
- C. Preparing Galvanized Railings for Shop Priming: After galvanizing, thoroughly clean railings of grease, dirt, oil, flux, and other foreign matter, and treat with etching cleaner and as follows.
 - 1. Comply with SSPC-SP 16.
- D. For nongalvanized-steel railings, provide nongalvanized ferrous-metal fittings, brackets, fasteners, and sleeves; however, hot-dip galvanize anchors to be embedded in exterior concrete or masonry.
- E. Preparation for Shop Priming: Prepare uncoated ferrous-metal surfaces to comply with SSPC-SP 6/NACE No. 3.
 - 1. Railings Indicated To Receive Zinc-Rich Primer: SSPC-SP 6/NACE No. 3.
 - 2. Railings Indicated To Receive Primers Specified in Section 099600 "High-Performance Coatings": SSPC-SP 6/NACE No. 3.
 - 3. Other Railings: SSPC-SP 3.

- F. Primer Application: Apply shop primer to prepared surfaces of railings unless otherwise indicated. Comply with requirements in SSPC-PA 1 for shop painting. Primer need not be applied to surfaces to be embedded in concrete or masonry.

1. Shop prime uncoated railings with **universal shop primer** unless "Single-Coat Superior Performance FEVE Organic Finish" Paragraph below is unsuitable for seacoast and severe environments.

2.7 EXAMINATION

- A. Examine plaster and gypsum board assemblies, where reinforced to receive anchors, to verify that locations of concealed reinforcements are clearly marked for Installer. Locate reinforcements and mark locations if not already done.

2.8 INSTALLATION, GENERAL

- A. Perform cutting, drilling, and fitting required for installing railings.
1. Fit exposed connections together to form tight, hairline joints.
 2. Install railings level, plumb, square, true to line; without distortion, warp, or rack.
 3. Set railings accurately in location, alignment, and elevation; measured from established lines and levels.
 4. Do not weld, cut, or abrade surfaces of railing components that are coated or finished after fabrication and that are intended for field connection by mechanical or other means without further cutting or fitting.
 5. Set posts plumb within a tolerance of 1/16 inch in 3 feet (2 mm in 1 m).
 6. Align rails so variations from level for horizontal members and variations from parallel with rake of steps and ramps for sloping members do not exceed 1/4 inch in 12 feet (6 mm in 3.5 m).
- B. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.
1. Coat concealed surfaces of aluminum that will be in contact with grout, concrete, masonry, wood, or dissimilar metals, with a heavy coat of bituminous paint.
- C. Adjust railings before anchoring to ensure matching alignment at abutting joints.
- D. Fastening to In-Place Construction: Use anchorage devices and fasteners where necessary for securing railings and for properly transferring loads to in-place construction.

2.9 RAILING CONNECTIONS

- A. Non-welded Connections: Use mechanical or adhesive joints for permanently connecting railing components. Use wood blocks and padding to prevent damage to

railing members and fittings. Seal recessed holes of exposed locking screws, using plastic cement filler colored to match finish of railings.

- B. Welded Connections: Use fully welded joints for permanently connecting railing components. Comply with requirements for welded connections in "Fabrication" Article, whether welding is performed in the shop or in the field.
- C. Expansion Joints: Install expansion joints at locations indicated but not farther apart than required to accommodate thermal movement. Provide slip-joint internal sleeve, extending 2 inches (50 mm) beyond joint on either side; fasten internal sleeve securely to one side; and locate joint within 6 inches (150 mm) of post.

2.10 ANCHORING POSTS

- A. Use stainless steel pipe sleeves preset and anchored into concrete for installing posts. After posts are inserted into sleeves, fill annular space between post and sleeve with **nonshrink, nonmetallic grout or anchoring cement**, mixed and placed to comply with anchoring material manufacturer's written instructions.
- B. Form or core-drill holes not less than 5 inches (125 mm) deep and 3/4 inch (20 mm) larger than OD of post for installing posts in concrete. Clean holes of loose material, insert posts, and fill annular space between post and concrete with **nonshrink, nonmetallic grout or anchoring cement**, mixed and placed to comply with anchoring material manufacturer's written instructions.
- C. Cover anchorage joint with flange of same metal as post, **welded to post after placing anchoring material**.
- D. Leave anchorage joint exposed with **anchoring material flush with adjacent surface**.
- E. Anchor posts to metal surfaces with flanges, angle type, or floor type, as required by conditions, connected to posts and to metal supporting members as follows:
 - 1. For steel railings, weld flanges to post and bolt to metal supporting surfaces.
 - 2. For aluminum railings, attach posts as indicated, using fittings designed and engineered for this purpose.
 - 3. For stainless steel railings, weld flanges to post and bolt to supporting surfaces.
- F. Install removable railing sections, where indicated, in slip-fit stainless steel sockets cast in concrete.

2.11 ATTACHING RAILINGS

- A. Anchor railing ends to metal surfaces with flanges bolted to metal surfaces and **welded to railing ends**.

- B. Attach handrails to walls with wall brackets, **except where end flanges are used**. Provide brackets with **1-1/2-inch (38-mm)** clearance from inside face of handrail and finished wall surface.
 - 1. Use type of bracket with flange tapped for concealed anchorage to threaded hanger bolt.
 - 2. Locate brackets as indicated or, if not indicated, at spacing required to support structural loads.
- C. Secure wall brackets and railing end flanges to building construction as follows:
 - 1. For concrete and solid masonry anchorage, use drilled-in expansion shields and hanger or lag bolts.
 - 2. For hollow masonry anchorage, use toggle bolts.
 - 3. For wood stud partitions, use hanger or lag bolts set into studs or wood backing between studs. Coordinate with carpentry work to locate backing members.
 - 4. For steel-framed partitions, use hanger or lag bolts set into **fire-retardant-treated** wood backing between studs. Coordinate with stud installation to locate backing members.
 - 5. For steel-framed partitions, fasten brackets directly to steel framing or concealed steel reinforcements, using self-tapping screws of size and type required to support structural loads.
 - 6. For steel-framed partitions, use toggle bolts installed through flanges of steel framing or through concealed steel reinforcements.

2.12 REPAIR

- A. Touchup Painting:
 - 1. Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with the same material used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
 - a. Apply by brush or spray to provide a minimum 2.0-mil (0.05-mm) dry film thickness.
- B. Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in **Section 099000 Painting**.

2.13 CLEANING

- A. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas, and repair galvanizing to comply with ASTM A780/A780M.

2.14 PROTECTION

- A. Protect finishes of railings from damage during construction period with temporary protective coverings approved by railing manufacturer. Remove protective coverings at time of Substantial Completion.
- B. Restore finishes damaged during installation and construction period, so no evidence remains of correction work. Return items that cannot be refinished in the field to the shop; make required alterations and refinish entire unit, or provide new units.

END OF SECTION 055213

SECTION 06 1000 - ROUGH CARPENTRY

PART 1 - GENERAL

1.1 SUMMARY:

- A. Work of this section includes rough carpentry and blocking as indicated in drawings.
- B. Related work specified elsewhere:
 - 1. Concrete formwork.
 - 2. Finish Carpentry and Millwork.
 - 3. Gypsum board.
 - 4. Toilet accessories.
 - 5. Roofing.

1.2 ACTION SUBMITTALS:

- A. Product Data: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.
 - 1. Include data for wood-preserved treatment from chemical treatment manufacturer and certification by treating plant that treated plywood complies with requirements. Indicate type of preservative used and net amount of preservative retained.
 - 2. Include data for fire-retardant treatment from chemical treatment manufacturer and certification by treating plant that treated plywood complies with requirements. Include physical properties of treated materials.
 - 3. For fire-retardant treatments, include physical properties of treated plywood both before and after exposure to elevated temperatures, based on testing by a qualified independent testing agency according to ASTM D5516-09.
 - 4. For products receiving a waterborne treatment, include statement that moisture content of treated materials was reduced to levels specified before shipment to Project site.
 - 5. Include copies of warranties from chemical treatment manufacturers for each type of treatment.

1.3 INFORMATIONAL SUBMITTALS:

- A. Evaluation Reports: For following products, from ICC-ES:
 - 1. Preservative-treated plywood.
 - 2. Fire-retardant-treated plywood.

1.4 QUALITY ASSURANCE:

- A. Applicable standards:
 - 1. ASTM International (ASTM), standards as referenced herein.
 - 2. Wood products; comply with the following standards published by the U. S. Department of Commerce, National Bureau of Standards:
 - a. Lumber: PS 20-10.
 - b. Construction and Industrial Plywood: PS 1-95.
 - 3. Preservative-treated wood: American Wood Protection Association (AWPA); current standards, as referenced herein, shall apply to preservative-treated wood products.
 - 4. Plywood: APA The Engineered Wood Association (APA), current standards.
 - 5. Grading rules; current grading rules of the following associations apply as applicable to wood products:
 - a. Southern Pine Inspection Bureau (SPIB).
 - b. Western Wood Products Association (WWPA).
 - c. West Coast Lumber Inspection Bureau (WCLIB).
 - d. National Lumber Grades Authority (NLGA).

- B. Product identification:
1. Lumber: Lumber shall bear the grade stamp of a listed grading rules association certified by the Board of Review of the American Lumber Standards Committee (ALSC), identifying species or species combination, grade, moisture condition at time of surfacing, mill of origin and grading agency.
 2. Plywood: Plywood shall bear the stamp of the APA The Engineered Wood Association (APA), indicating type, grade, thickness, exposure durability, span rating, agency compliance, species group, edging, finish and glue type.
 3. Preservative-treated wood products: Preservative-treated lumber and plywood shall bear the quality standard stamp of the applicator, indicating preservative type, exposure conditions, year of treatment, treatment plant and treatment supervising agency.
 4. Fire-retardant-treated wood products: Fire-retardant-treated lumber and plywood shall bear the stamp of Underwriters Laboratories, Inc., (UL) or other approved independent inspection agency, indicating treatment type or name, flame spread and treatment plant.

1.5 DELIVERY, STORAGE AND HANDLING:

- A. Upon delivery to project site, place materials in areas protected from weather.
- B. Store materials a minimum of 6" above ground on blocking and cover with waterproof covering. Provide for air circulation and ventilation.
- C. Store no seasoned materials in wet or damp portions of building.
- D. Protect sheet materials from breaking corners and damaging surfaces.

PART 2 - PRODUCTS

2.1 LUMBER:

- A. Species and standards: Grade-stamped commercial softwood conforming to PS 20 and referenced grading rules, unless otherwise indicated.
- B. Seasoning: 19% maximum moisture content at time of building enclosure, unless otherwise noted.
- C. Surfacing: Surfaced four sides (S4S).
- D. Dimensions: Indicated lumber dimensions are nominal. Comply with PS 20.
- E. Framing lumber; 2" to 4" thickness, 2" to 4" wide, any commercial softwood species, except as noted:
 1. Plates, blocking, bracing and nailers: Utility Grade or #3 Southern Pine.
 2. General framing: Standard Grade or #2 Southern Pine.
 3. General utility purposes: Utility Grade or #3 Southern Pine.

2.2 SHEET MATERIALS:

- A. Engineered Wood Products, General: Products shall contain no urea formaldehyde.
- B. Plywood:
 1. Plywood Backing Panels: For mounting electrical or telephone equipment, provide fire-retardant-treated plywood panels with grade, C-D Plugged Exposure 1, in thickness indicated or, if not otherwise indicated, not less than 3/4" thick.
 2. Plywood: Exterior type, APA A-C EXT, thickness indicated on drawings.

3. Plywood wall panels at IDF/MDF Room Mounting Boards: PS 1 A-D plywood, or medium density fiberboard; 3/4" thick; flame spread index of 25 or less, smoke developed index of 450 or less, when tested in accordance with ASTM E84-18.
 - a. Cover walls floor to ceiling, with fire-rated 3/4-inch plywood and painted with two coats of neutral color fire-retardant paint specified in Section 09 9100 - Painting and Coating.

2.3 TREATED WOOD PRODUCTS:

- A. Pressure-preservative-treated wood:
 1. Treatment type: Water-borne preservative registered with EPA.
 2. AWP standard:
 - a. Lumber, timber and plywood shall conform to applicable requirements of AWP Standard U1-07 and T1-07 for species, product and end use.
 - b. Handling and care of pressure treated wood products shall conform to AWP Standard M4-06.
 - c. Preservatives shall conform to AWP P5-07.
 3. Preservative retention: As required by treatment type in accord with AWP Standards for below- or above-ground use.
 4. Seasoning; re-dry after treatment to 19% maximum moisture content.
 5. Use:
 - a. Wood products in contact with concrete slabs-on-grade or foundations.
 - b. Nailers or blocking cast or built into concrete or masonry.
 - c. Wood products in contact with exterior walls.
 - d. Blocking, nailers, plates and similar wood products in conjunction with roof decks, roofing and roof parapets.
- B. Interior fire-retardant-treated wood:
 1. Acceptable product; subject to compliance with specified requirements:
 - a. Hickson Corporation, Dricon.
 - b. Hoover Treated Wood Products, Pyro-Guard.
 - c. Viance, LLC, D-Blaze.
 2. Description: Pressure-impregnated with a chemical retardant tested and listed by Underwriters Laboratories, Inc., (UL). When tested in accord with ASTM E84-12a treated products shall have a flame spread of 25 or less and show no evidence of significant progressive combustion when the test is continued for an additional twenty minute period. In addition, flame front shall not progress more than 10'-6" beyond centerline of burners at any time during test.
 3. Surface burning characteristics: F.R.-S rating in accord with Underwriters Laboratories, Inc. (UL).
 4. AWP standard: AWP U1-07, T1-07 and P17-02.
 5. Seasoning; kiln-dried after treatment to the following maximum moisture content:
 - a. Lumber: 19%.
 - b. Plywood: 15%.
 6. Hygroscopicity: Maximum 28% equilibrium moisture content when tested in accord with ASTM D3201-08a at 92% relative humidity.
 7. Use: As required by codes.

2.4 HARDWARE:

- A. Provide nails, bolts, nuts, washers, screws, expansion bolts, clips, powder-actuated fasteners and similar hardware necessary for complete installation of rough carpentry items.
 1. Material and finish for use with non-pressure treated and fire-retardant-treated components shall be G90 hot dip galvanized steel or Type 304 stainless steel, except nails shall be hot dip galvanized.
 2. Material and finish for use with pressure-preservative-treated components shall be one of the following:
 - a. G185 hot-dip galvanized steel.
 - b. Type 316L stainless steel.

PART 3 - EXECUTION

3.1 WORKMANSHIP:

- A. Install wood framing and rough carpentry work cut square on bearings, fitted and set to required lines and levels, and secured in place.
- B. Lay out the work to provide correct openings to receive work of other trades.
- C. Preservative-treated wood:
 - 1. Prior to installation, brush-apply preservative to cut edges and ends of wood, using same type of preservative used for pressure treatment.
 - 2. Handle and install in accord with AWWPA standards.
- D. Fire-retardant-treated wood:
 - 1. Prevent exposure to water or moisture, and do not use if so exposed.
 - 2. Only end cuts shall be made. Do not rip or re-surface.
 - 3. Attach using only hot dip galvanized nails and anchors.
- E. Plates, blocking, nailers and miscellaneous framing:
 - 1. Provide 2" nominal thickness members to support and secure finishing materials, fixtures, toilet accessories and grab bars, partitions, specialty items and trim.
 - 2. Bolt to structural steel or metal framing at 4'-0" o. c., maximum.
 - 3. Secure to concrete and masonry using cast-in bolts, powder-activated stud, sleeve or wedge type anchors spaced at 4'-0" o. c., maximum.
 - 4. Provide anchors within 3" of ends of members.
 - 5. Provide linear runs in maximum practicable lengths, with joints in multiple members offset 3'-0", minimum.
 - 6. Around roof perimeter and at roof penetrations, provide blocking equal to roof insulation thickness. Attach through decking into structural members at 2'-0" o. c., maximum, starting within 3" of each end. Space ends 1/2" for venting.
 - 7. Provide wood blocking behind grab bars and toilet accessories.
- F. Site tolerances:
 - 1. Variation from plumb: 1/4" in 10'-0" height, non-cumulative,
 - 2. Variation from horizontal squaring diagonals: 1/2".
 - 3. Variation from indicated location of framing: $\pm 1/4"$.
 - 4. Location of dimensioned openings: $\pm 3/8"$.
 - 5. Variation from indicated rough opening size: +1/4", -1/8".

END OF SECTION

SECTION 06 1643 - EXTERIOR SHEATHING

PART 1 - GENERAL

1.1 SUMMARY:

- A. Section Includes:
 - 1. Plywood and gypsum wall sheathing.
 - 2. Sheathing joint and penetration treatment.

1.2 ACTION SUBMITTALS:

- A. Product Data: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.
 - 1. For products receiving a waterborne treatment, include statement that moisture content of treated materials was reduced to levels specified before shipment to Project site.

1.3 INFORMATIONAL SUBMITTALS:

- A. Evaluation Reports: For the following, from ICC-ES:
 - 1. Preservative-treated wood.
 - 2. Fire-retardant-treated wood.
 - 3. Post-installed anchors.
- B. Warranties: Include copies of warranties from chemical treatment manufacturers for each type of treatment.

1.4 DELIVERY, STORAGE, AND HANDLING:

- A. Stack panels flat with spacers beneath and between each bundle to provide air circulation. Protect sheathing from weather by covering with waterproof sheeting, securely anchored. Provide for air circulation around stacks and under coverings.

1.5 WARRANTIES:

- A. Fiberglass-faced gypsum sheathing:
 - 1. Provide manufacturer's standard warranty for sheathing to be free of manufacturing defects including, but not limited to, delamination, sagging and warping. Warranty period shall be five years, beginning at Date of Substantial Completion.
 - 2. Provide manufacturer's standard warranty for sheathing to remain free of delamination, sagging and warping, and stating that sheathing will remain suitable for its intended purpose under normal weathering conditions when left exposed. Warranty period shall be six months, beginning upon application of sheathing.

PART 2 - PRODUCTS

2.1 WOOD PANEL PRODUCTS:

- A. Plywood: Either DOC PS 1 or DOC PS 2 unless otherwise indicated.
 - 1. Wall sheathing: APA Rated Sheathing, Exterior, Exposure 1, Group 1, thickness indicated.
 - 2. Roof Sheathing: APA Structural I Rated Sheathing, Exterior, 48/24 or 40/20, 3/4" thick; veneer plywood only.
- B. Thickness: As needed to comply with requirements specified, but not less than thickness indicated.
- C. Factory mark panels to indicate compliance with applicable standard.

2.2 FIBERGLASS-FACED GYPSUM SHEATHING:

- A. Acceptable products:
 - 1. Basis of design; G-P Gypsum Products, Dens-Glass Gold Gypsum Sheathing.
 - 2. CertainTeed Corp., GlasRoc Sheathing.
 - 3. National Gypsum, Gold Bond eXP Extended Exposure Sheathing.
 - 4. United States Gypsum Co., Securock Glass-Mat Sheathing.
- B. Characteristics:
 - 1. Composition: Conforming to ASTM C1177-08; incombustible, silicone treated and water-resistant gypsum core with inorganic fiberglass mat face treated with alkali-resistant polymer coating.
 - 2. Type: Minimum 5/8" thickness. Face size shall be 4'-0" wide by 8'-0", 9'-0" or 10'-0" length, square ends and edges.
 - 3. Weight: Minimum 2300 lbs./msf.
 - 4. Mold resistance: Resistant to mold growth when tested in accord with ASTM D3273-12.
- C. Joint tape: 2" wide 10x10 glass mesh tape in accord with sheathing manufacturer's product data.
- D. Fasteners: Screws for application of fiberglass-faced gypsum sheathing to cold-formed metal framing shall be minimum 1-1/4" long, No. 6, Type S or S-12, non-corrosive coated bugle head, self-drilling fasteners complying with ASTM C1002-07 and ASTM C954-11.
- E. Joint sealant: Medium modulus silicone sealant as specified in Section 07 9200 - Joint Sealants.

2.3 FIRE-RATED FIBERGLASS FACED GYPSUM SHEATHING:

- A. Acceptable products:
 - 1. CertainTeed Corp., GlasRoc Sheathing, Type X.
 - 2. G-P Gypsum Products, Dens-Glass Gold FireGuard Gypsum Sheathing.
 - 3. National Gypsum, Gold Bond eXP Extended Exposure Fire-Shield Sheathing.
 - 4. United States Gypsum Co., Securock Firecode Type X Glass-Mat Sheathing.
- B. Characteristics:
 - 1. Composition: Conforming to ASTM C1177-13; noncombustible water-resistant core, essentially gypsum, surfaced with glass mat partially or completely embedded in the core.
 - 2. Mold resistance: Resistant to mold growth when tested in accord with ASTM D3273-12.
 - 3. Type: Type X Grade fire-rated board, minimum 5/8" thickness. Face size shall be 4'-0" wide by 8'-0", 9'-0" or 10'-0" length, square ends and edges.
 - 4. Weight: Minimum 2300 lbs./msf.
- C. Fasteners: Screws for application of fiberglass-faced gypsum sheathing to cold-formed metal framing shall be minimum 1-1/4" long, non-corrosive coated, self-drilling fasteners as recommended by manufacturer, complying with ASTM C1002-14 and ASTM C954-11.
- D. Power-driven fasteners: Fastener systems with an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC70.
- E. Joint treatment and air barrier: Install in accord with Section 07 2726 - Fluid-Applied Vapor-Permeable Air Barriers.

2.4 FASTENERS:

- A. General: Provide fasteners of size and type indicated that comply with requirements specified in this article for material and manufacture.
- B. Power-Driven Fasteners: NES NER-272.

- C. Screws for Fastening Wood Structural Panels to Cold-Formed Metal Framing: ASTM C954-11, except with wafer heads and reamer wings, length as recommended by screw manufacturer for material being fastened.
 - 1. For wall sheathing panels, provide screws with organic-polymer or other corrosion protective coating having a salt-spray resistance of more than 800 hours according to ASTM B117-11.
 - 2. Material and finish for use with pressure-preservative-treated components shall be Type 316L stainless steel.

PART 3 - EXECUTION

3.1 EXAMINATION:

- A. Examine installed framing and furring members to receive sheathing to verify that surfaces of framing and furring to receive sheathing does not vary more than 1/8" from adjacent surfaces.

3.2 INSTALLATION, GENERAL:

- A. Do not use materials with defects that impair quality of sheathing or pieces that are too small to use with minimum number of joints or optimum joint arrangement. Arrange joints so that pieces do not span between fewer than three support members.
- B. Cut panels at penetrations, edges, and other obstructions of work; fit tightly against abutting construction unless otherwise indicated.
- C. Securely attach to substrate by fastening as indicated, complying with the following:
 - 1. NES NER-272 for power-driven fasteners.
 - 2. Table 2304.9.1, "Fastening Schedule," in ICC's "International Building Code."
- D. Coordinate wall and roof sheathing installation with flashing and joint-sealant installation so these materials are installed in sequence and manner that prevent exterior moisture from passing through completed assembly.
- E. Do not bridge building expansion joints; cut and space edges of panels to match spacing of structural support elements.
- F. Coordinate sheathing installation with installation of materials installed over sheathing so sheathing is not exposed to precipitation or left exposed at end of the workday when rain is forecast.

3.3 WOOD STRUCTURAL PANEL INSTALLATION;

- A. General: Comply with applicable recommendations in APA Form No. E30, "Engineered Wood Construction Guide," for types of structural-use panels and applications indicated.
- B. Fastening Methods: Fasten wall sheathing panels as indicated below:
 - 1. Screw to cold-formed metal framing.
 - 2. Space panels 1/8" apart at edges and ends.

3.4 INSTALLATION OF GYPSUM SHEATHING:

- A. Install gypsum sheathing in accord with manufacturer's product data and applicable provisions of GA-253, and ASTM C1280-12a and as follows.
- B. Install exterior gypsum sheathing specified herein with colored or logo side facing out to weather.
- C. Use maximum lengths possible to minimize number of joints. Stagger vertical joints. Terminate vertical edges over framing members.

- D. Space fasteners in accord with manufacturer's product data. Install fasteners so heads bear tight against face of sheathing boards but do not cut into facing.
- E. Seal sheathing joints using specified sheathing joint tape and sealant in accord with sheathing board manufacturer's product data.
- F. Fasteners may be reduced during sheathing installation when attachment of subsequent materials will provide specified attachment spacing and will follow sheathing installation immediately.

END OF SECTION

SECTION 06 2200 - FINISH CARPENTRY AND MILLWORK

PART 1 - GENERAL

1.1 SUMMARY:

- A. Work of this section includes factory-fabricated woodwork as follows:
 - 1. All finish carpentry items including finish carpentry, millwork and casework/cabinetry, plastic laminate, casework hardware, miscellaneous millwork, finish hardware.
 - 2. Plastic laminate casework.
- B. Related work: Painting.

1.2 ACTION SUBMITTALS:

- A. Shop drawings: Submit for architectural woodwork. Indicate construction and installation details, species and grades of materials, finishes, plastic laminate and cabinet hardware selections. Indicate layout of architectural paneling.
- B. Product data: Submit for cabinet hardware and similar manufactured items. Submit with shop drawings.
- C. Samples; submit as follows:
 - 1. Plastic laminate: Manufacturer's standard color and pattern selections for selection by Architect.
 - 2. Finish samples: Submit one sample of each type of selected finish on samples of species and grade material specified.
 - 3. Hardware items: Submit if requested by Architect. Samples will be returned to supplier.

1.3 INFORMATIONAL SUBMITTALS:

- A. Fire-retardant treatment certification: Submit for Architect's information only. Submit certification by treating plant that fire retardant treatment materials comply with governing ordinances and that treatment will not bleed through finished surfaces.
- B. AWI Certification: Submit AWI Quality Certification Program certificates indicating that the woodwork provided for this project complies with the requirements of the AWS Grades specified.

1.4 QUALITY ASSURANCE:

- A. Applicable standards; comply with the following:
 - 1. Standards of the following, as referenced herein:
 - a. American National Standards Institute (ANSI).
 - b. APA The Engineered Wood Association (APA).
 - c. ASTM International (ASTM).
 - d. American Wood Protection Association (AWPA).
 - e. Forest Stewardship Council (FSC).
 - f. Hardwood Plywood and Veneer Association (HPVA).
 - g. National Electric Manufacturers Association (NEMA).
 - h. National Fire Protection Association (NFPA).
 - i. Underwriters Laboratories, Inc., (UL).
 - 2. Wood products; standards of the U. S. Department of Commerce, National Institute of Standards and Testing:
 - a. Lumber: PS 20-10.
 - b. Construction and Industrial Plywood: PS 1-95.

3. Standards for architectural woodwork: Architectural Woodwork Institute (AWI), "Architectural Woodwork Standards, 2nd Edition, October 1, 2014, herein referred to as AWS Standards. Work shall comply with applicable portions of AWS standards.
- B. Grade marks: Identify lumber and plywood by official grade mark.
 1. Lumber: Grade stamp shall contain symbol of grading agency, mill number or name, grade of lumber, species or species grouping or combination designation, rules under which graded where applicable, and condition of seasoning at time of manufacture.
 2. Plywood: Appropriate grade trademark of the APA. Indicate type, grade, class, identification index and inspection and testing agency mark.
 3. Preservative-treated wood products: Preservative-treated lumber and plywood shall bear the quality standard stamp of the applicator, indicating preservative type, exposure conditions, year of treatment, treatment plant and treatment supervising agency.
 4. Fire-retardant-treated wood products: Fire-retardant-treated lumber and plywood shall bear UL stamp or stamp of other approved independent inspection agency, indicating treatment type or name, flame spread and treatment plant
 5. On components to be exposed to view, grade marks shall be located so as to be concealed in finished work.
- C. Fabricator/installer qualifications: Architectural woodwork shall be fabricated and installed by a single manufacturer.
 1. Fabricator/installer shall have at least five years successful experience in the fabrication, finishing and installation of architectural woodwork of the type and quantity required and, if requested by Architect, shall submit evidence of such experience,

1.5 DELIVERY, STORAGE AND HANDLING:

- A. Deliver no woodwork to project site until areas are ready for woodwork installation.
- B. Immediately upon delivery to job site, place woodwork indoors, protected from weather.
- C. Store woodwork a minimum of 6" above floor on blocking and cover with waterproof covering. Provide for air circulation and ventilation. Store in dry, conditioned space.
- D. Wrap prefinished woodwork in protective covering for shipping and storage. Protect from sunlight exposure.

1.6 PROJECT CONDITIONS:

- A. Field measurements: Take field measurements to ascertain exact woodwork sizes. Indicate exact dimensions on shop drawings.
- B. Install no interior woodwork until spaces are enclosed, dry and conditioned. Maintain temperature between 55 degrees F. and 80 degrees F. for 72 hours before beginning installation and afterwards until Date of Substantial Completion.
- C. Maintain interior relative humidity at the site between 25% and 55% before, during, and after installation.

1.7 WARRANTY:

- A. Furnish five (5) year warranty for the work specified against becoming unserviceable or causing an objectionable appearance resulting from either defective or nonconforming materials or workmanship.

1. Defects shall include rough or difficult operation, or loose or missing parts, delamination of surfaces, noticeable deterioration of finish and warped or misaligned surfaces or telegraphing of subsurface imperfections.

PART 2 - PRODUCTS

2.1 MATERIALS; GENERAL:

- A. General: Provide materials that comply with requirements of AWS's quality standard for each type of woodwork and quality grade specified, unless otherwise indicated.

2.2 BASIC MATERIALS:

- A. Lumber for opaque finish:
 1. Species: Poplar.
 2. Lumber grade: Grade I.
 3. Moisture content: 8-13%.
 4. Locations: As indicated on drawings.
- B. Low-Emitting Materials:
 1. Hardboard: AHA A135.4; 1/4" thickness.
 2. Medium-density fiberboard (MDF):
 - a. Acceptable manufacturers:
 - 1) Flakeboard Co., South Carolina and Oregon.
 - 2) SierraPine, Oregon.
 - b. Characteristics: Meeting ANSI A208.2; Grade 130, minimum 40 pcf density; fire-retardant-treated, moisture-resistant, as scheduled. MDF shall have no added urea-formaldehyde resins.
 3. Particleboard: Meeting ANSI A208.1, Grade M3-Exterior glue; mat-formed, manufactured of long fibered cuttings, weighing minimum of 45 lbs./cu. ft.; fire-retardant-treated (FR), meeting NFPA 101; moisture-resistant (MR); filled on faces to be painted, made with binder containing no urea formaldehyde.
 4. Plywood:
 - a. Veneer-Faced Panel Products (Hardwood Plywood): HPVA HP-1 and AWP A P17-02, made with adhesive containing no urea formaldehyde.
 - b. Softwood plywood: DOC PS 1, Medium Density Overlay.
 5. Countertop core at sink areas shall be of 3/4" marine grade plywood and shall have 24 hour thickness swell factor of five percent or less and 24 hour water absorption factor of ten percent or less; P.S. 51, Type II or better.
- C. PL-1; Plastic laminates:
 1. Acceptable products:
 - a. Formica Corporation.
 - b. Chemetal Metal Laminates
 - c. Lab Design Architectural Laminates.
 - d. PL-1; Basis of design; Wilsonart International; Div. of Premark International, Inc.
 2. Conforming to NEMA Standard LD3-2005, as follows:
 - a. Horizontal applications: Grade HGS.
 - b. Vertical applications: Grade VGS.
 - c. Cabinet-liner: Grade CL-20.
 - d. Backing sheet: Grade BKL, undecorated plastic laminate.
 - e. Post-forming applications: Grade HGP.
 - f. Chemical resistant applications: Grade VGP.
 - g. Solid color applications: Grade HGS.
 3. PL-1; Colors, textures and patterns: Wilsonart Asian Night 7949K-18.

- D. Thermoset decorative panels: Particleboard or medium-density fiberboard finished with thermally fused, melamine-impregnated decorative paper complying with LMA SAT-1.
 - 1. Provide 3mm PVC or polyester edge banding complying with LMA EDG-1 on components with exposed or semi-exposed edges and doors and drawers only.
 - 2. Color: White melamine interior.
 - 3. Location: Cabinet interiors.

2.3 ARCHITECTURAL CABINETS/CASEWORK:

- A. Architectural cabinets shall comply with AWS Standards, Section 10.
- B. Plastic laminate clad cabinets:
 - 1. AWS quality grade: Custom.
 - 2. Panel core: Fire-retardant-treated particleboard or hardwood plywood.
 - 3. Finish on exposed surfaces: Plastic laminate as specified herein.
 - 4. Finish on semi-exposed surfaces: Plastic laminate cabinet liner.
 - 5. Component edges: Plastic laminate faced.
 - 6. Cabinet and door faces: Grain to run vertically.
- C. Tops:
 - 1. AWS quality grade; Custom for plastic laminate and solid surfacing and Premium for transparent finish.
 - 2. Plastic laminate:
 - a. Exposed surfaces: Plastic laminate.
 - b. Core: Medium density fiberboard or particleboard.
 - c. Non-exposed surface: Backing sheet.
 - 3. Counters without sinks/lavatories: Medium density fiberboard (MDF); moisture-resistant.
 - 4. Sink top cores: Countertop core at sink areas shall be of 3/4" marine grade plywood and shall have 24 hour thickness swell factor of five percent or less and 24 hour water absorption factor of ten percent or less; P.S. 51, Type II or better.

2.4 MISCELLANEOUS WOODWORK:

- A. Comply with AWS Standards as follows:
 - 1. Standing and running trim, including, but not limited to, base, and frames: Section 6, Custom Grade for opaque (painted) finish.
 - 2. Storage shelving: Section 6, Economy Grade, except Custom Grade for strength.

2.5 TREATED WOOD PRODUCTS:

- A. Pressure-preservative-treated wood:
 - 1. Treatment type: Water-borne preservative registered with EPA.
 - 2. AWPA standard:
 - a. Lumber, timber and plywood shall conform to applicable requirements of AWPA Standard U1-07 and T1-07 for species, product and end use.
 - b. Handling and care of pressure treated wood products shall conform to AWPA Standard M4-06.
 - c. Preservatives shall conform to AWPA P5-07.
 - 3. Preservative retention: As required by treatment type in accord with AWPA Standards for below- or above-ground use.
 - 4. Seasoning; re-dry after treatment to 19% maximum moisture content.
 - 5. Use:
 - a. Wood products in contact with concrete slabs-on-grade or foundations.
 - b. Nailers or blocking cast or built into concrete or masonry.
 - c. Wood products in contact with exterior walls.
- B. Interior fire-retardant-treated wood:
 - 1. Acceptable product; subject to compliance with specified requirements:
 - a. Hickson Corporation, Dricon.

- b. Hoover Treated Wood Products, Pyro-Guard.
 - c. Viance, LLC, D-Blaze.
 2. Description: Pressure-impregnated with a chemical retardant tested and listed by Underwriters Laboratories, Inc., (UL). When tested in accord with ASTM E84-18b treated products shall have a flame spread of 25 or less and show no evidence of significant progressive combustion when the test is continued for an additional twenty minute period. In addition, flame front shall not progress more than 10'-6" beyond centerline of burners at any time during test.
 3. Surface burning characteristics: F.R.-S rating in accord with Underwriters Laboratories, Inc. (UL).
 4. AWP standard: AWP U1-07, T1-07 and P17-02.
 5. Seasoning; kiln-dried after treatment to the following maximum moisture content:
 - a. Lumber: 19%.
 - b. Plywood: 15%.
 6. Hygroscopicity: Maximum 28% equilibrium moisture content when tested in accord with ASTM D3201-08a at 92% relative humidity.
 7. Use: As required by codes.

2.6 HARDWARE:

- A. All hardware shall meet ANSI A156.9. All keying shall match existing master key system and be approved by the Owner.
- B. Exposed Hinges:
 1. Acceptable manufacturers: Hafele America, "Hafele 5-K Five Knuckle, 354.65.420 HNG" Institutional Pivot Cabinet Hinge Grade 1 with 270° Opening Angle for 3/4" thick overlay door. Shall meet ANSI/BHMA A156.9 Grade 1 requirements; mill ground, hospital tip, Teflon coated tight pin feature with all edges eased. Hinge shall be full wrap around type of tempered steel 0.095 inch thick. Each hinge shall have minimum of 9 screws, #7, 5/8 inch FHMS to assure positive door attachment. . One pair per door to 48 inch height. Hinge shall allow 270 degree swing.
 2. Finish: US26D, dull chrome plated finish.
- C. Stainless steel door and drawer pulls: Chrome wire pulls, unless noted otherwise.
 1. Type: 3-1/2" (96 mm) long wire pull.
- D. Magnetic catches: Mill finished aluminum.
 1. Acceptable manufacturers:
 - a. Basis of design: Stanley Works #SP41.
 - b. Epco, Inc.
 - c. Sugatsune America, Inc.
- E. Standard duty recessed shelf standards and supports: Pilaster for built-in shelving and bookcase applications. Adjustable on 1/2" centers. 19 gauge steel, 5/8" wide x 3/16" high.
 1. Acceptable manufacturers:
 - a. Basis of design: Knappe and Vogt Mfg. Co., #255 gauge standard with #256 support.
 - b. Stanley Works.
 - c. Sugatsune America, Inc.
 2. Type: Steel.
 3. Finish: As selected by Architect.
- F. Heavy duty shelf standards and supports: Pilaster for built-in shelving and bookcase applications. Adjustable on 1" centers. 16 gauge steel, 5/8" wide x 13/32" high.
 1. Acceptable manufacturers:
 - a. Basis of design: Knappe & Vogt Mfg. Co., #80 standards with #180 brackets.
 - b. Stanley Works.
 - c. Sugatsune America, Inc.

2. Type: Steel.
 3. Finish: As selected by Architect.
- G. Shelf Pins: ROK Hardware, 5mm Chrome Spoon.
- H. Pencil drawer slides:
1. Accuride "2009"; hold-open detent and adjustable bracket; 3/4 travel.
 2. Grant "512"; no hold-open and nonadjustable bracket; 3/4 travel.
 3. K & V "1240"; no hold-open and nonadjustable bracket; 3/4 travel.
- I. Side mount drawer slides:
1. Acceptable products:
 - a. Basis of design: Accuride, #3832.
 - b. Grant Hardware Co., #5632.
 - c. Knappe and Vogt Mfg. Co., #1429.
 2. Type: Full extension, steel ball bearing.
 3. Capacity: 100 lb. capacity:
- J. Cabinet drawer/door lock:
1. Acceptable products:
 - a. Knappe and Vogt Mfg. Co., #986.
 - b. Sugatsune America, Inc., #3310.
 - c. Timberline Supply, Ltd., Style CB-230 deadlock and Type 230 cylinder body with lock plug.
 2. Finish: Nickel-plated.
- K. Trash/Recycling Grommets: Doug Mockett TM10B, 10" satin stainless steel.
1. Provide set including grommet, grommet cap and slot cover.
- L. Fasteners: Provide bolts, nails, screws, toggle bolts and similar fasteners as indicated or required to attach and secure work.
1. Fasteners for trim shall be finishing nails for attachment to wood framing, trim-head screws for attachment to metal framing.
 2. Material and finish for non-pressure treated and fire-retardant-treated components shall be G90 hot dip galvanized steel or Type 304 stainless steel, except nails shall be hot dip galvanized.
 3. Material and finish for pressure-treated components shall be G185 hot-dip galvanized steel or Type 316L stainless steel.

2.7 ADHESIVES:

- A. Adhesives, general:
1. Adhesives shall not contain urea formaldehyde.
 2. Adhesives used in cabinets installed adjacent to slide-in ranges must have a temperature rating of at least 194 degrees.
- B. VOC limits for installation adhesives: Installation adhesives shall comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
1. Wood glues: 30 g/L.
 2. Multipurpose construction adhesives: 70 g/L.
 3. Contact adhesive: 80 g/L.
 - a. Adhesive for bonding plastic laminate: Use a PVA water resistant adhesive. Contact adhesives not permitted.
 - b. Adhesive for bonding edges: Hot-melt adhesive or adhesive specified above for faces.

2.8 FABRICATION:

A. General:

1. Quality grade for finish carpentry and millwork shall be AWS Custom Grade.
2. Fabricate finish carpentry and millwork in accord with approved shop drawings.
3. Apply laminate backing sheet to reverse side of plastic laminate finished surfaces.
4. Seal faces and edges of medium density fiberboard indicated to be sealed or finished.
5. Shop-assemble for delivery to site in units easily handled and to permit passage through building openings. Items which cannot be manufactured in one piece shall have joints at logical breaking points and shall be so noted on shop drawings.
6. Apply plastic laminate sheets in full uninterrupted sheets consistent with manufactured sizes. Fit corners and joints hairline; secure with concealed fasteners.
7. Flat Edge PVC edging shall be 0.020 inch. Solid, high-impact, purified, color thru, acid resistant, machine-applied with hot melt adhesives. 3 mm PVC shall be solid, high-impact, purified, color-thru, acid resistant, pre-lamination primed edging, machine-applied with hot melt adhesives, and machine profiled to 1/8" radius. To be used at doors and drawers and shelf edges only.
8. When necessary to cut and fit on site, provide materials with ample allowance for cutting. Provide trim for scribing and site cutting.
9. Scribe, miter and accurately join members.
10. Finish work shall be smooth, free from abrasion, tool marks, open joints or raised grain on exposed surfaces.

B. Casework:

1. Fit shelves, doors and exposed edges with matching plastic laminate edging. Use one piece for full length only.
2. Where countertops can not be provided in single length, join using compression type fasteners.
3. Provide cutouts for plumbing fixtures, inserts, appliances, outlet boxes, fixtures and fittings. Verify locations of cutouts from onsite dimensions. Seal contact surfaces of cut edges.

PART 3 - EXECUTION

3.1 PREPARATION:

- A. Prior to pre-installation conference, examine substrates and conditions to receive work. Check that floors and wall substrates are level, plumb and within tolerances to receive work specified in this section.
- B. Verify mechanical, electrical and building items affecting work of this section are placed and ready to receive architectural woodwork.
- C. Do not begin work until unsatisfactory substrates or conditions have been corrected.
- D. Pre-installation conference:
 1. Prior to beginning work, a pre-installation conference will be held to review work to be accomplished.
 2. Contractor, fabricator/installer and Architect shall be present.
 3. Contractor's submittals will be reviewed.
 4. Substrates and conditions under which woodwork shall be installed will be reviewed.
 5. Contractor shall notify all parties at least seven days prior to time of conference.
 6. Contractor shall record minutes of meeting and distribute to all parties in attendance.

3.2 JOB MOCK-UP:

- A. Erect a full size mock-up of cabinet work at project site for Architect's acceptance. If unacceptable, erect additional mock-ups until acceptable.
- B. Mock-up shall indicate the following:
 - 1. Workmanship.
 - 2. Finishes.
 - 3. Relationships to adjacent work.
 - 4. Do not begin woodwork production until each mock-up has been accepted by Architect.
- C. Accepted, undamaged mock-ups may remain as part of the finished work.

3.3 GENERAL WORKMANSHIP:

- A. Install woodwork in a manner consistent with the specified Quality Grade, plumb, level, true and straight within 1/8" in 10'-0". Shim as required using concealed shims.
- B. Secure to grounds, stripping and blocking with countersunk, concealed fasteners and blind nailing.
 - 1. Use fixture attachments in concealed locations for wall mounted components.
 - 2. Secure cabinet and counter base to floor using angles and anchorages.
- C. Scribe and cut for accurate fit to other finished work, with maximum gap of 1/32". Do not use addition overlay trim to conceal larger gaps.
- D. Use concealed joint fasteners to align and secure adjoining cabinet units and countertops.
- E. Before making cutouts, drill pilot holes at corners.
- F. Finish work shall be smooth, free from abrasion, tool marks, raised grain grade markings or similar defects on exposed surfaces.
- G. Distribute defects allowed in the quality grade specified to the best overall advantage when installing job assembled work. Install work in accord with approved shop drawings.
- H. Touch up mill finished items, including refinishing necessitated by job fitting or attaching and repair of scratches and similar damages. Touch up repairs shall be indiscernible in the finished work.

3.4 FIELD FINISHING:

- A. Field finish: Field finish painted woodwork in accord with the requirements of the Section 09 9100 - Painting and Coating. Prior to finishing, sand using 120 to 180 grit abrasive on a smooth sanding block, to remove scuff and handling marks, raised grain, scratches and effects of moisture exposure.

3.5 CLEANING AND PROTECTION:

- A. Protect finished and prefinished surfaces from work of other trades.
- B. Prior to Date of Substantial Completion, examine work for damages. Repair or replace such damaged work to original condition.
- C. Clean laminate, metal and accessory items using a neutral cleaner. Check and correct operating mechanism for proper operation. Adjust and lubricate hinges, catches and other operating hardware.

END OF SECTION

SECTION 06 6116 - SOLID SURFACING FABRICATIONS

PART 1 - GENERAL

1.1 SUMMARY:

- A. Work of this section includes:
 - 1. Lavatory tops.
 - 2. Countertops.
 - 3. Window sills.

1.2 REFERENCES:

- A. Applicable standards: Standards of the following, as referenced herein:
 - 1. American National Standards Institute (ANSI).
 - 2. ASTM International (ASTM).

1.3 ACTION SUBMITTALS:

- A. Shop drawings: Indicate dimensions, component sizes, fabrication details attachment provisions and coordination requirements with adjacent work.
- B. Samples: Submit minimum 6" by 6" samples. Indicate full range of color and pattern variation. Approved samples will be retained as a standard for work.
- C. Product data: Indicate product description, fabrication information and compliance with specified performance requirement.

1.4 CLOSEOUT SUBMITTALS:

- A. Maintenance data: Submit manufacturer's care and maintenance data, including repair and cleaning instructions. Include in project closeout documents.

1.5 QUALITY ASSURANCE:

- A. Job mock-up:
 - 1. Prior to final approval of shop drawings, erect at project site, for Architect's review, one full size mock-up of each component required.
 - 2. Should mock-up not be approved, re-fabricate and re-install until approval is secured. Remove rejected units from project site.
 - 3. Approved mock-ups may remain as part of finished work.

1.6 DELIVERY, STORAGE AND HANDLING:

- A. Deliver no components to project site until areas are ready for installation. Store indoors.
- B. Handle materials to prevent damage to finished surfaces. Provide protective coverings to prevent physical damage or staining following installation for duration of project.

1.7 WARRANTY:

- A. Provide manufacturer's warranty against defects in materials. Warranty shall provide for replacement material and labor for a period of ten (10) years, beginning at Date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SS-1; QUARTZ SOLID SURFACING MATERIAL:

- A. Acceptable products:
 - 1. Cambria USA.
 - 2. Caesarstone US.

3. E. I. du Pont de Nemours & Co., Inc.
 4. SS-1 Basis of design; Silestone, Quartz.
- B. Material: Homogeneous quartz surfacing material.
1. Material shall be through-patterned and homogeneous. No coated materials nor non-homogeneous materials allowed.
 2. Hardness: Minimum 7 Mohs Hardness scale.
 3. Flexural strength: Minimum 5,300 psi, tested in accord with ASTM D790-03.
 4. Abrasion resistance: 175-250 range when tested in accord with ASTM C501-84(2002).
 5. Fire resistance: Flame spread and smoke developed meeting ASTM E84-04, Class I rating, and NFPA 255 Class A rating.
 6. High temperature resistance: None to slight effect when tested in accord with NEMA LD-3-3.6.
 7. Boiling water resistance: None to slight effect when tested in accord with NEMA LD-3-3.8.
 8. Colorfastness: Passes ANSI Z124.6.5.1.
 9. Wear and cleanability: Passes ANSI Z124.6.3.
 10. Stain resistance: Passes ANSI Z124.6, with ratings of 5.2 for stain resistance, 5.5 for chemical resistance, and 5.4 for cigarette resistance.
 11. Water absorption: Maximum 0.04%, when tested in accord with ASTM C97-02 and ASTM D570-98.
 12. Fungal resistance: No attack when tested in accord with ASTM G21-96(2002).
 13. Bacterial resistance: No attack.
 14. Impact resistance: No fracture when tested in accord with NEMA LD 3-3.3, 164" drop.
- C. Characteristics:
1. Composition: Quartz aggregate, resin, and color pigments formed into flat slabs. Quartz content shall be minimum 93%.
 2. SS-1; Colors: Series Net Zero; Blanco Maple 14.
 3. Thickness: Minimum 1-1/2" thick; with eased straight edge.
 4. Tops:
 - a. Provide configurations indicated. Provide full-length units for lengths shorter than 10'-0".
 - b. Provide backsplashes, endsplashes and aprons as indicated.
 - c. Bowls shall be undermount (underslung) porcelain bowls as specified in Division 22, Plumbing.
 5. Joint sealer/adhesive: Manufacturer's recommended low-VOC joint sealer/adhesive, colors as selected by Architect from surfacing manufacturer's full color range.

2.2 SS-2; CAST ACRYLIC SOLID SURFACING:

- A. Acceptable products:
1. SS-2 Basis of design; E. I. du Pont de Nemours & Co., Inc., Corian.
 2. Avonite, Foundations.
 3. Hanwha L&C Surfaces, Hanex
 4. Wilsonart International, Solid Surface.
 5. Silestone.
 6. L G. Hausys, H-Macs.
- B. Material: Cast, 100% acrylic resin, solid, structural surfacing material.
1. Material shall be through-patterned and homogeneous. No coated materials nor non-homogeneous materials allowed.
 2. Hardness: Minimum 55 Barcol hardness, tested in accord with ASTM D2583-07, or minimum 90 Rockwell hardness, tested in accord with ASTM D785-08.
 3. Tensile strength: Minimum 4,200 psi, tested in accord with ASTM D638-10.
 4. Abrasion resistance: Maximum 0.4 grams at 1,000 cycles, tested in accord with ASTM C501-84(2009).
 5. Fire resistance: Flame spread and smoke developed meeting ASTM E84-12c, Class I rating.
 6. Color stability: No change in 200 hours, tested in accord with NEMA LD3-2005.

7. Water absorption: Maximum 0.06%, tested in accord with ASTM D570-98(2010).
 8. Fungal resistance: No attack when tested in accord with ASTM G21-09.
 9. Bacterial resistance: No attack when tested in accord with ASTM G22-76(1996)(withdrawn 2001).
 10. Impact resistance: No fracture when tested in accord with NEMA LD3; Section 3.3, 144" drop.
 11. Superficial damage to a depth of 0.10" shall be repairable by sanding and polishing.
- C. Window sill characteristics:
1. Finish: Matte or semi-gloss as selected by Architect.
 2. Thickness: Minimum 3/4" with 1-1/2" thick with eased, straight edge; size, profile, and location as indicated on drawings.
 3. SS-2 Color: Corian, Terra Collection, Bisque Color.

2.3 ACCESSORY PRODUCTS:

- A. Joint adhesive: Manufacturer's standard, two-part adhesive kit to create inconspicuous, non-porous joints, with a chemical bond.
- B. Sealant: Manufacturer's standard mildew-resistant, FDA/UL recognized silicone sealant in color matching surfacing or clear formulations.
- C. Sink/bowl mounting hardware: Manufacturer's approved bowl clips, brass inserts and fasteners for attachment of undermount porcelain sinks/bowls.
- D. Window sill mounting hardware: Manufacturer's approved sill clips and fasteners for attachment to window framing and supports.

2.4 FABRICATION:

- A. Factory-fabricate components to greatest extent practicable, to sizes and shapes indicated, in accord with approved shop drawings.
- B. Form joints between components using manufacturer's standard joint adhesive; without conspicuous joints and without voids. Attach a 2" wide reinforcing strip of solid surfacing under each joint.
- C. Provide factory cutouts for plumbing fittings and bath accessories as indicated.
- D. Rout and finish component edges to a smooth, uniform finish. Rout cutouts and sand edges smooth. Machine radii and contours to template. Repair or reject defective and inaccurate work.
- E. Edge treatment for tops: 1-1/2" edge as indicated on drawings.

2.5 SOURCE QUALITY CONTROL:

- A. Allowable tolerances:
1. Variation in component size: $\pm 1/8"$.
 2. Location of openings: $\pm 1/8"$ from indicated location.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. Install components plumb, level and rigid, scribed to adjacent finishes, in accord with approved shop drawings and product data.
1. Tops:
 - a. Flat and true to within 1/8" of a flat surface over a 10'-0" length.
 - b. Allow a minimum of 1/16" to a maximum of 1/8" clearance between surface and each wall.

- c. Form field joints using manufacturer's recommended adhesive, with joint widths no greater than 1/8" in finished work.
- B. Sinks: Adhere porcelain undermount sinks/bowls to countertops using proper adhesive, sealant, and mounting hardware.
- C. Provide backsplashes and endsplashes as indicated on the drawings.
 - 1. Adhere to countertops using manufacturer's standard color-matched silicone sealant.
- D. Keep components and hands clean during installation.
 - 1. Remove adhesives, sealants and other stains.
 - 2. Components shall be clean on Date of Substantial Completion.
- E. Make plumbing connections to porcelain undermount sinks/bowls in accord with Division 22, Plumbing.
- F. Install window sills to window framing and supports using specified adhesive, sealants and mounting hardware.

3.2 PROTECTION:

- A. Protect surfaces from damage until Date of Substantial Completion. Repair or replace damaged work which cannot be repaired.

END OF SECTION

SECTION 07 2100 - THERMAL INSULATION

PART 1 - GENERAL

1.1 SUMMARY:

- A. Related work:
 - 1. Concrete.
 - 2. Cementitious decks.
 - 3. Roofing system.
 - 4. Roof insulation.
 - 5. Firestopping.
 - 6. Joint sealants.
 - 7. Acoustical insulation.
 - 8. Mechanical insulation.

1.2 ACTION SUBMITTALS:

- A. Product data: Submit product data and installation instructions for each type installation. Include product data for manufacturer's recommended sheathing joint tape.
- B. Samples: Submit minimum 1'-0" by 1'-0" sample of sprayed insulation in standard color as selected by Architect.

1.3 INFORMATIONAL SUBMITTALS:

- A. Certification: Submit manufacturer's certification that expanded polystyrene wall insulation meets specified density and fire resistance requirements.

1.4 QUALITY ASSURANCE:

- A. Applicable standards:
 - 1. ASTM International (ASTM), standards as specified herein.
 - 2. NFPA 285, Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Non-Load-Bearing Wall Assemblies Containing Combustible Components Using the Intermediate-Scale, Multistory Apparatus.

PART 2 - PRODUCTS

2.1 BATT INSULATION:

- A. Batt insulation at metal stud walls:
 - 1. Walls:
 - a. Unfaced fiberglass batts complying with ASTM C665-12, Type I, rated minimum R-13 for thermal resistance.
 - b. Surface burning characteristics: Flame spread of 25 or less and smoke developed 50 or less when tested in accord with ASTM E84-13a.
 - c. Formaldehyde content: Zero.
 - d. Width: Equal to framing spacing.
 - 2. Soffits:
 - a. Unfaced fiberglass batts complying with ASTM C665-12, Type I; rated R-19 for thermal resistance.
 - b. Surface burning characteristics: Flame spread of 25 or less and smoke developed 50 or less when tested in accord with ASTM E84-13a.
 - c. Critical radiant flux: 0.12 W/cm² (0.11 Btu/ft²-s) when tested in accord with ASTM E970-10.
 - d. Formaldehyde content: Zero.
 - e. Width: Equal to framing spacing.
 - 3. Acceptable products; subject to compliance with specified requirements:
 - a. Owens-Corning; Ecotouch Pink Fiberglass.
 - b. CertainTeed; CertaPro Series.

- B. Acoustical insulation: Refer to Section 09 2900 - Gypsum Board.
- C. Tape: Insulation manufacturer's standard foil-faced tape; width required to cover joints.
- D. Fasteners: Stick-clip spindle fasteners; spindle length as required for insulation thickness.

2.2 EXTRUDED POLYSTYRENE CAVITY WALL AND CONTINUOUS INSULATION:

- A. Acceptable products; subject to compliance with specified requirements:
 - 1. The Dow Chemical Co., Styrofoam, Cavitymate.
 - 2. Owens-Corning, Foamular 250, Square Edge.
 - 3. Kingspan, GreenGuard CM XPS Insulation Board.
- B. Characteristics:
 - 1. Material: Extruded, closed cell polystyrene boards complying with ASTM C578-13, Type X.
 - 2. Fire propagation characteristics: Insulation shall have been tested and passed NFPA 285 with regard to vertical and lateral fire propagation as part of an approved assembly.
 - 3. Thickness: 2".
 - 4. Density: 1.3 pcf, minimum.
 - 5. Aged R value at 75 degrees F.: 5.0/in. for Total R-7.5.
 - 6. Surface burning characteristics: Flame spread of 25 or less and smoke developed 450 or less when tested in accord with ASTM E84-13a.
 - 7. Compressive strength: 15 minimum, tested in accord with ASTM D1621-10.
 - 8. Flexural strength: Minimum 40 psi.
 - 9. Water vapor permeance: Maximum 1.5 perm-inch, tested in accord with ASTM E96-13.
 - 10. Water absorption: Maximum 0.3% by volume.
 - 11. Sizes: 1'-4" by 8'-0".
 - 12. Edges: Square.
- C. Adhesive, joint sealant and joint tape: As recommended by insulation manufacturer.

2.3 SEMI-RIGID INSULATION:

- A. Acceptable products; subject to compliance with specified requirements:
 - 1. CertainTeed Corp., CertaPro Commercial Board CB 225 FSK.
 - 2. Johns Manville International, Inc., Insul-Shield FSK-25 I/S 225.
 - 3. Owens-Corning, Curtainwall Insulation/CW225.
- B. Characteristics:
 - 1. Material: 2.25 pcf density fiberglass with reinforced foil-scrim-kraft facing complying with ASTM C612-11.
 - 2. Thickness: Indicated on drawings.
 - 3. Size: 2'-0" by 4'-0".
 - 4. R value at 75 degrees F.: 4.3/in. minimum.
 - 5. Surface burning characteristics: Flame spread of 25 or less and smoke developed 50 or less when tested in accord with ASTM E84-13a.
 - 6. Perm rating: 0.05 or less when tested in accord with ASTM E96-13.
 - 7. Formaldehyde content: Zero.
- C. Fasteners: Stick-clip spindle fasteners; spindle length as required for insulation thickness.
- D. Tape: Insulation manufacturer's standard foil-faced tape; width required to cover joints.

2.4 SPRAYED THERMAL INSULATION, METAL SOFFITS:

- A. Closed-cell sprayed polyurethane insulation:
 - 1. Acceptable products; subject to compliance with specified requirements:
 - a. BASF Corp., SprayTite Spray Polyurethane Foam Insulation.

- b. Dow Chemical Co., Styrofoam Spray Polyurethane Foam Insulation.
 - c. Gaco Western, Gaco 183M Spray Polyurethane Foam Insulation.
 - d. Henry Co., Permax Spray Polyurethane Foam Insulation.
 - e. Icynene, Inc., Icynene ProSeal Spray Polyurethane Foam Insulation.
 - f. NCFI Polyurethanes, Insulstar Spray Polyurethane Foam Insulation.
 2. Type: Two or three component closed-cell polyurethane foam insulation meeting ASTM C1029-13, providing tight adhesive bond with substrates, minimum 2.0 pcf density.
 3. Thickness and thermal value: Minimum R-Value of 6 per inch when tested in accord with ASTM C518-10. Provide minimum 6-1/2" total thickness, with final thermal value of R-38.
 4. Fire rating: 2 hrs. when tested in accord with ASTM E119-14.
 5. Surface burning characteristics: Flame spread of 25 or less, smoke developed of 450 or less when tested in accord with ASTM E84-15.
 6. Water vapor permeability: 2.3 perms per inch when tested in accord with ASTM E96-14.
 7. Water absorption by volume: Maximum 1.7% when tested in accord with ASTM D2842-12.
 8. Air infiltration: Maximum 0.004 cfm/sf at pressure of 1.57 psf, when tested in accord with ASTM E2178-11.
 9. Closed cell content: Minimum 96% when tested in accord with ASTM D6226-10.
 10. Compressive strength: Minimum 26 psi when tested in accord with ASTM D1621-10.
 11. Blowing agents: Blowing agents shall not contain formaldehyde, CFCs, Penta-BDEs or VOCs.
- B. Thermal barrier where required:
1. Basis of design; Isolatek International, CAFCO® TB 415™ Medium-Density Thermal Barrier.
 2. Characteristics:
 - a. Type: Medium-density wet-mix portland cement based product.
 - b. V.O.C.: VOC compliant.
 - c. Product shall have passed certified testing for both the (UL-1715) 15 minute Thermal Barrier and the NFPA 286 (AC-377 standards) as an Ignition Barrier.
 - d. Coverage rates: As required to comply with and pass the following:
 - 1) UL 1715 Thermal Barrier at 3/8" thickness.
 - 2) ASTM E84, at 3/8" thickness.
 - 3) ASTM E119/UBS 26-2; at 3/4" thickness.
 - e. Surfacing burning characteristics per ASTM E84::
 - 1) Flame: 25.
 - 2) Smoke: 450.
 - f. Density: ASTM E605: 2 pcf.
 - g. Cohesion/Adhesion: ASTM E736; 434 psf.
 - h. Cohesion/Adhesion over SPF: 1,135 psf tested performance under controlled conditions of independent laboratory tests.
 3. Other acceptable products:
 - a. International Fireproof Technology, Inc., DC315.
 - b. Specialty Products, Inc. (SPI), Flamesafe - TB.
 - c. TPR Corp. (Thermal Product Research), Fireshell F10E.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. General: Comply with manufacturer's product data for each type installation. Install insulation fitted to adjacent construction and with tight joints to provide unbroken thermal barrier. Cut insulation around obstructions and protrusions; fill voids with insulation. Remove projections interfering with installation.

- B. Batt insulation:
 - 1. Install batt insulation in exterior walls and soffits as indicated. Friction fit unfaced insulation and secure with tension wires.
 - 2. Install batt insulation with butted joints.
- C. Extruded polystyrene cavity wall and continuous insulation:
 - 1. Secure extruded polystyrene insulation to substrates using adhesive of type recommended by insulation manufacturer.
 - 2. Install with end and edge joints butted tightly over clean, dry surfaces, using full application of adhesive applied in uniform thickness.
 - 3. Seal vertical and horizontal edges using sealant or joint tape as recommended by the insulation manufacturer.
 - 4. Install optional masonry tie washers at continuous insulation to prohibit penetrating and crushing of insulation.
- D. Semi-rigid spandrel insulation:
 - 1. Friction fit rigid fiberglass insulation. After installation of insulation, secure with insulation manufacturer's clip utilizing center notches to secure directly on the wire ties as shown in manufacturer's installation instructions.
 - 2. Friction fit insulation between studs; typically at 16" o.c. Then secure insulation with insulation manufacturer's plastic clip.
 - 3. Install rigid fiberglass insulation with butted joints; tape joints when required to meet Energy Code for Ci requirements.
- E. Sprayed polyurethane foam insulation: Apply spray foam insulation to underside of the concrete in metal soffits and other areas as shown on the drawings.
 - 1. Applicator shall be trained, certified and approved by insulation manufacturer.
 - 2. Areas to receive spray foam insulation shall be ventilated with fresh air and exhausting air continuously during and 24 hours after spray foam insulation application. Prevent spray and vapors from migrating into non-application areas.
 - 3. Surfaces to receive sprayed insulation shall be clean, dry and free from dirt, dust, grease, oil, loose paint, rust scale, projections, loose material and other conditions which would prevent adhesion.
 - 4. Spray apply insulation material in accord with manufacturer's product data and application procedures to achieve insulation thickness specified.
 - 5. Protect insulated areas from damage and moisture for the remainder of the construction period.
 - 6. Allow insulation to fully cure before covering with finish materials.
 - 7. Thermal barrier coating: Apply coating to sprayed polyurethane foam insulation in accord with manufacturer's product data to comply with requirements of UL-1715 and International Building Code requirement 2603.4 for 15 minute thermal barrier over foam plastic.

END OF SECTION

SECTION 07 4113 - CANOPY METAL ROOF PANELS

PART 1 - GENERAL

1.1 SUMMARY:

- A. Work of this section includes formed custom inverted seam roof panels of type and profile indicated over waterproof underlayment, nailable sub-base underlayment and insulation; and all related flashing, trims and accessories.
- B. Related work specified elsewhere:
 - 1. Structural steel.
 - 2. Metal roof decks.
 - 3. Metal fabrications.
 - 4. Rough carpentry.
 - 5. Sheet metal flashing and trim.

1.2 DESIGN AND PERFORMANCE CRITERIA:

- A. Thermal movement: Completed metal roofing and flashing system shall be capable of withstanding expansion and contraction of components caused by a temperature range from -10°F. to +150°F. without buckling, producing excess stress on structure, anchors or fasteners, or reducing performance.
- B. Uniform wind load capacity: Installed roof system shall withstand positive and negative design wind loading pressures complying with the International Building Code, 2012 Edition with a maximum system deflection of L/120 and a maximum panel deflection of 0.04%.
 - 1. Design Wind Loads; ASCE 7:
 - a. Wind loads for an ultimate wind speed of 150 mph 3-second gust.
 - b. Exposure: Exposure B.
 - c. Risk Category: III (ASCE 7 Method).
- C. Structural wind uplift resistance: Roof assembly shall withstand positive and negative air pressure testing in accord with ASTM E1592-05(2012) using uniform static air pressure testing methods.
- D. Static pressure air infiltration: Completed roof system shall have maximum of 0.09 cfm/sq. ft. with 6.24 psf air pressure differential in accord with ASTM E1680-11.
- E. Water Penetration: Provide manufactured roof panel assemblies with no water penetration as defined in the test method when tested according to ASTM E1646-95(2011) at a minimum differential pressure of 20 percent of inward acting, wind-load design pressure of not less than 6.24 lb/sq. ft. and not more than 12.0 lb/sq. ft.
- F. Capacities for gauge, span or loading other than those tested may be determined by interpolation of test results within the range of test data. Extrapolation for conditions outside test range are not acceptable.

1.3 ACTION SUBMITTALS:

- A. Shop drawings: Shall be prepared by or approved by manufacturer.
 - 1. Indicate roof system with flashings and accessories in plan and elevation; sections and details at full scale.
 - 2. Indicate metal thicknesses and finishes, panel lengths, joining details, anchorage details, flashings and special fabrication provisions for termination and penetrations, girt locations, expansion provisions and supports.

3. Indicate relationships with adjacent and interfacing work.
 4. Indicate location of penetrations with relation to rib placement.
- B. Product data: Include manufacturer's detailed material and system description, installation instructions, engineering performance data and finish specifications.
- C. Samples:
1. Submit samples of panel section, at least 2'-0" in length by full width, indicating thickness, profile, texture and color.
 2. Submit samples of panel clips, closures and accessory items.

1.4 INFORMATIONAL SUBMITTALS:

- A. Certification:
1. Submit certification that proposed applicator is approved for warranted work by metal roof manufacturer.
 2. Submit certification from authorized representative of metal roof manufacturer, stating that surfaces and conditions are acceptable for purpose of providing specified warranty.
 3. Submit certification from authorized representative of metal roof manufacturer, stating that proposed roof system meets design and performance criteria, and specified requirements.
 4. Submit certification from authorized representative of metal roof manufacturer that specified metal roof systems have been satisfactorily installed on projects of similar scope and size and have been completed for five years.
 5. Certification: Submit written certification that fluoropolymer coating complies with specified performance requirements.
 6. Submit certification from manufacturer that fabricator/installer is approved and certified to fabricate/install manufacturer warranted metal roof systems as specified herein.
- B. Design calculations: Submit design calculations, indicating compliance with specified performance criteria. Indicate fastener types and spacings. Design calculations shall bear the seal of a professional Engineer licensed in the State of Texas. Indicate that Engineer has reviewed shop drawings.
- C. Test reports:
1. Submit reports by an independent testing laboratory to support structural calculations and show compliance with specified performance criteria.
 2. Tests shall have been made for substantially identical systems within the ranges of specified performance criteria.
 3. If test data is not available or if data does not represent project conditions, Contractor shall be responsible for securing satisfactory tests by an independent testing agency acceptable to Architect, with costs of such testing borne by the Contractor.

1.5 QUALITY ASSURANCE:

- A. Applicable standards; standards of the following, as referenced herein:
1. American Architectural Manufacturers Association (AAMA).
 2. ASTM International (ASTM).
 3. National Roofing Contractors Association (NRCA), "The NRCA Roofing Manual: Metal panel and SPF Roof Systems-2012".
 4. Sheet Metal and Air Conditioning Contractors National Association (SMACNA), "Architectural Sheet Metal Manual," Seventh Edition - January, 2012.
 5. Society for Protective Coatings (SSPC).
 6. Underwriters Laboratories, Inc. (UL).

- B. Manufacturer's qualifications:
 - 1. Metal roof system manufacturer shall have been engaged in the manufacture of metal roof systems similar to those specified herein for a minimum of ten years.
 - 2. Manufacturer shall submit evidence that his proposed metal roof system as specified herein has been satisfactorily installed on projects of similar scope and size, which have been completed for at least five years.
- C. Fabricator/installer qualifications:
 - 1. Fabricator/installer shall be trained and approved by metal roof system manufacturer, with trained supervisory personnel observing and directing the work.
 - 2. If required, proposed fabricator/installer shall submit evidence of financial responsibility.
 - 3. Architect reserves the right to inspect fabrication facilities in determining qualifications.
 - 4. Fabricator/installer shall have satisfactorily installed metal roof systems, similar in size and scope to the specified system, which have been completed for five years.
 - 5. Fabricator/installer shall be approved and certified to install metal roof systems which can be warranted by metal roof manufacturer.

1.6 DELIVERY, STORAGE AND HANDLING:

- A. Protect components during fabrication, shipment, storage, handling and erection from mechanical abuse, stains, discoloration and corrosion.
- B. Maintain strippable plastic protective film on finished surfaces until panels are erected.
- C. Handle materials to prevent damage to surfaces, edges and ends of roofing sheets and sheet metal items. Damaged material shall be rejected and removed from site.
- D. Protect panels from wind-related damages.
- E. Inspect materials upon delivery. Reject and remove physically damaged or marred material from project site.
- F. Do not overload roof structure with stored materials. Do not permit material storage or traffic on completed roof surfaces.

1.7 PROJECT/SITE CONDITIONS:

- A. Protection:
 - 1. Provide protection or avoid traffic on completed roof surfaces.
 - 2. Avoid overloading roof with stored materials.
 - 3. Support no roof-mounted equipment directly on roofing system.
- B. Ascertain that work of other trades which penetrates roof or is to be made watertight by roof is in place and approved prior to installation of roofing.

1.8 WARRANTIES:

- A. Endorse and forward to Owner the following warranties:
 - 1. Manufacturer's twenty year finish warranty covering refinishing of fluoropolymer coating due to checking, crazing, peeling, chalking or fading.
 - 2. Installer's two year warranty covering roofing system installation and watertightness.
 - 3. Warranties shall commence on Date of Substantial Completion.

PART 2 - PRODUCTS

2.1 METAL ROOFING SYSTEMS:

- A. Basis of design; Overly Manufacturing Company, "Custom EVOLUTION Roof System", roof system without raised battens; featuring concealed fasteners and a continuous internal drain channel.
 - 1. Gutter System: Provide metal gutter system with welded/soldered seams and expansion joints.
 - 2. Movement: Provide for independent movement of all roof components consistent with a thermal range of 120 degrees F and consistent with anticipated movement of building structure.
 - 3. Replacement of Panels: Provide for the non-destructive selection removal and replacement of individual roof sheets.
 - 4. Panel system shall have continuous extruded internal drainage channel and gasket and compression cover cap.
- B. Other acceptable manufacturers: Subject to compliance with specified criteria and Architect's acceptance, products by other manufacturers may be submitted for Architect's consideration.

2.2 MATERIALS:

- A. Sheets: Aluminum 18 gauge (0.040 inches) 3003-H14 alloy with a two coat Pvd2 finish in a standard color as selected by the architect.
 - 1. Panel Infill Board is shipped from factory with metal roof panel and is to be installed prior to metal panels. This high density cover board material is a half-inch (12.7mm) thick, 80 psi minimum density rated polyisocyanurate foam with coated glass face.
 - 2. Panel size:
 - a. Width: Maximum extrusion center is 4'-0".
 - b. Length: Maximum panel length is 30'-0".
- B. Internal Drainage Channel and Compression Cover Plate: Overly type "EVOLUTION"; 0.056 inches thick minimum and 0.125 inches nominal thickness, each in a 6063 alloy aluminum T-5 temper.
- C. Fasteners: System fasteners shall be concealed and no less than a #12 stainless steel wood screw shall be used to anchor the internal drain channel; length as required for substrate construction.
- D. Finish:
 - 1. Exposed surfaces finish:
 - a. Exposed aluminum components: Two coat, shop-applied, baked-on, MICA fluoropolymer coating system based on minimum 70% Arkema Group, Kynar 500 or Solvay Solexis, Inc., Hylar 5000 resin (Polyvinylidene fluoride, PVDF), or Valspar Lumifon FEVE coating system, formulated by a licensed manufacturer and applied by manufacturer's approved applicator to meet AAMA 2605.
 - b. Colors: Matching Alucobond "Beachstone Gray Metallic".
 - 2. Finish on unexposed surfaces: Mill finish.
- E. Waterproof underlayment:
 - 1. Acceptable products; subject to compliance with specified requirements:
 - a. Carlisle Coatings and Waterproofing, Inc., WIP 300HT.
 - b. Polyguard Products, Inc., Polyguard Deck Guard HT.
 - c. GCP Applied Technologies, Ice & Water Shield HT (High-Temperature).

2. Characteristics:
 - a. Type: Self-adhering rubberized asphalt sheet complying with ASTM D1970-09.
 - b. Thickness: Minimum 40 mils when tested in accord with ASTM D3767-03(2008), method A.
 - c. Tensile strength: 250 psi minimum when tested in accord with ASTM D412-06a.
 3. Elongation: 250% when tested in accord with ASTM D412-06a, Die C Modified.
 4. Provide primers, sealants and accessories required for a waterproof installation.
- F. Accessories:
1. Anchor clips: Stainless steel or hot-dipped galvanized steel, G-90 coating designation, designed to receive mechanical anchor into decking, structural support elements, girts or blocking. Clips shall allow free thermal expansion and contraction movement, relative to the structure, within the full temperature ranges specified.
 2. Anchors: Stainless steel screws designed to meet structural loading requirements.
 3. Exposed fasteners: Stainless steel self-tapping hexagonal head screws with neoprene sealing washers, #14 size, minimum; head finished to match panel color.
 4. Closures: Manufacturer's standard closed cell foam or sheet metal "Z" closure:
 - a. Closed cell foam shall meet ASTM D1056-07, Type 2, Class D or ASTM D3575-08; factory-cut foam shall be enclosed in metal channels matching panels when used at hip and ridge.
 - b. "Z" closures shall be same material as panels, manufacturer's standard detail, with continuous sealant bead at edges, ends and contact area with adjacent materials.
 5. Provide miscellaneous accessories for complete installation. Accessories shall be furnished by roof system manufacturer.
- G. Plywood roof decking: Refer to Section 06 1000 - Rough Carpentry.
- H. Paper Slip Sheet: 5-lb/square red rosin, sized building paper conforming to FS UU-B-790, Type 1, Style 1b.
- I. Tape: 3M™ VHB™ Construction Tape, 3M™ VHB™ Architectural Panel Tapes utilize multi-purpose acrylic adhesive on both sides of a conformable, foam core. The combination of strength and conformability is specifically designed for good adhesion to metals, glass and other medium to high surface energy materials.
- J. Structural sealant: Structural sealant at edge trim and other indicated locations.
1. Acceptable products:
 - a. Dow Chemical Company, DOWSIL 995 Silicone Structural Sealant.
 - b. Pecora, Corp., 895.
 - c. Tremco, Inc., Proglaze SSG.
 2. Type: Single-component, non-sag, neutral-cure, medium modulus silicone sealant; meeting ASTM C920-14a, Type S, Grade NS, Class 50, for Use NT, and ASTM 1184-14.
 3. Colors: Black color for structural glazing.
 4. Provide primers as required by adhesion testing, backer rod and accessories acceptable to sealant manufacturer.

PART 3 - EXECUTION

3.1 PREPARATION:

- A. Pre-roofing conference: Prior to beginning metal roof work, hold a pre-roofing conference to review work to be accomplished.
 - 1. Contractor, Architect, metal roofing subcontractor, metal roof system manufacturer's representative and all subcontractors who have equipment penetrating roof or whose work involves access to roof shall be present.
 - 2. Contractor shall notify Architect and other attending parties at least seven days prior to time for conference.
 - 3. Contractor shall record minutes of meeting and shall distribute copies of minutes to attending parties.
- B. Examination:
 - 1. Examine alignment and placement of substrates before proceeding with installation of metal roof.
 - 2. Examine alignment and placement of penetrations before proceeding with installation of metal roof.
- C. Install waterproof membrane underlayment at all areas to receive metal.
 - 1. Install membrane underlayment fully adhered to substrates in accord with manufacturer's product data.
 - 2. If required, prime surfaces to receive membrane materials. Allow primer to dry until tack-free. Prime only area which can be covered with sheet membrane during work period. Reprime surfaces which are not covered within 24 hours of primer application.
 - 3. Install membrane materials with side and end laps lapped as recommended by product data. Begin installation at low points, lapping succeeding sheets to shed water.
 - 4. Membrane applications shall be fully adhered, smooth, straight and free of blisters, buckles, fishmouths and wrinkles affecting the complete adherence of the membrane. Patch and repair defective work in accord with manufacturer's product data. Replace defective areas.
 - 5. Double membrane at changes in plane by application of a centered membrane strip. Cover strip completely with full width sheet.
 - 6. Seal around protrusions and at terminations in accord with product data.
 - 7. Repair punctures and tears in membrane by patching with membrane material.
- D. Slip Sheet: Apply slip sheet over underlayment before installing metal roof panels.

3.2 ROOF INSTALLATION:

- A. Install roof and flashings in accord with approved shop drawings and manufacturer's product data, within specified erection tolerances.
 - 1. Penetrations shall occur in flat of panel.
- B. Isolate dissimilar metals and masonry or concrete from metals with bituminous paint. Use gasketed fasteners to prevent corrosive action between fastener, substrate and panels.
- C. Exposed fasteners shall be prefinished to match finish of panels and trim. Limit exposed fasteners to extent indicated on shop drawings.
- D. Anchorage shall allow for temperature expansion/contraction movement within specified range without stress or elongation of panels, clips or anchors. Attach clips to decking using self-drilling screws of size and spacing in accord with manufacturer's product data and design calculations to resist specified uplift and thermal movement forces.

- E. Install starter base materials and continuous internal drain channels to substrate.
- F. HD Infill Board is set in place between drain channels prior to the metal roof panel.
- G. Install panels between drain channel extrusions and anchor to substrate as required.
- H. Install the gasket to the compression cover and secure the assembly to the drain channel.
- I. Install and seal the cover cap securely over the compression plate to complete the standard installation.
- J. Complete installation by installing perimeter covers and flashings.
- K. Coordinate sheet metal flashing and trim work to provide weathertight conditions at roof terminations. Fabricate and install in accord with standards of SMACNA "Architectural Sheet Metal Manual" and NRCA "Metal Panel and SPF Roof Systems," using continuous cleats at all exposed edges.
- L. Provide for temperature expansion/contraction movement of panels at roof penetrations and roof-mounted equipment in accord with system manufacturer's product data and design calculations.
 - 1. Locate penetrations in flat of panel.
 - 2. Provide EPDM rubber flashing boots for vents, pipes, stacks, hoses and round legs of equipment supports. Mechanically attach base flange and tighten hose clamp to provide watertight installation.
- M. Installed system shall be true to line and plane and free of dents, oilcans and physical defects.

3.3 FIELD QUALITY CONTROL:

- A. Applicable erection tolerances; maximum variation from true planes or lines: 1/4" in 20'-0"; 3/8" in 40'-0" or more.
- B. Conduct 10 random fastener pull tests in accordance with this section in areas designed by the Owner's Authorized Representative, and submit test results for the comparison to design requirements.
- C. Block gutter drains and fill with water. Let stand for 24 hours. Repair gutter as required and retest until gutters are watertight.

3.4 CLEANING AND PROTECTING:

- A. Damaged Units: Replace panels and other components of the work that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.
- B. Cleaning: Remove temporary protective coverings and strippable films, if any, as soon as each panel is installed. On completion of panel installation, clean finished surfaces as recommended by panel manufacturer and maintain in a clean condition during construction.
- C. Protection: Do not permit unnecessary walking on finished roof. Require all personnel to wear rubber-soled shoes when walking on or installing this roof system.

- D. Remove protective film and clean exposed surfaces of roofing and accessories after completion of installation. Leave in clean condition at Date of Substantial Completion. Touch up minor abrasions and scratches in finish.

END OF SECTION

SECTION 07 6200 - SHEET METAL FLASHING AND TRIM

PART 1 - GENERAL

1.1 SUMMARY:

- A. Section Includes:
 - 1. Formed roof-drainage sheet metal fabrications.
 - 2. Formed low-slope roof sheet metal fabrications.
 - 3. Formed wall sheet metal fabrications.
- B. Related work specified elsewhere:
 - 1. Roofing system.
 - 2. Joint sealants.

1.2 PERFORMANCE REQUIREMENTS:

- A. General: Sheet metal flashing and trim assemblies shall withstand wind loads, structural movement, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Completed sheet metal flashing and trim shall not rattle, leak, or loosen, and shall remain watertight.
- B. Sheet metal standard for flashing and trim: Comply with NRCA's "The NRCA Roofing Manual" and SMACNA's "Architectural Sheet Metal Manual" requirements for dimensions and profiles shown unless more stringent requirements are indicated.
- C. SPRI wind design standard: Manufacture and install copings and roof edge flashings tested according to SPRI ES-1 and capable of resisting the following design pressure:
 - 1. Design pressure: As indicated on Drawings.
- D. Thermal movements: Allow for thermal movements from ambient and surface temperature changes to prevent buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 - 1. Temperature change: 120 deg F, ambient; 180 deg F, material surfaces.
- E. Wind Loads; ASCE 7:
 - 1. Wind loads for an ultimate wind speed of 150 mph 3-second gust.
 - 2. Exposure: Exposure B.
 - 3. Risk Category: III (ASCE 7 Method).

1.3 ACTION SUBMITTALS:

- A. Product Data: For each of the following
 - 1. Underlayment materials.
 - 2. Elastomeric sealant.
 - 3. Butyl sealant.
- B. Shop Drawings: For sheet metal flashing and trim.
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Detail fabrication and installation layouts and keyed details. Distinguish between shop- and field-assembled Work.
 - 3. Include identification of material, thickness, weight, and finish for each item and location in Project.
 - 4. Include details for forming, including profiles, shapes, seams, and dimensions.
 - 5. Include details for joining, supporting, and securing, including layout and spacing of fasteners, cleats, clips, and other attachments. Include pattern of seams.
 - 6. Include details of termination points and assemblies.
 - 7. Include details of roof-penetration flashing.
 - 8. Include details of edge conditions, including eaves, ridges, valleys, rakes, crickets, flashings, and counterflashings.

9. Include details of special conditions.
 10. Include details of connections to adjoining work.
- C. Samples: Sheet metal flashing, trim, and accessory items, in the specified finish. Where finish involves normal color and texture variations, include Sample sets composed of 2 or more units showing the full range of variations expected.
1. 8-inch-square Samples of specified sheet materials to be exposed as finished surfaces.
 2. 12-inch-long Samples of factory-fabricated products exposed as finished Work. Provide complete with specified factory finish

1.4 INFORMATIONAL SUBMITTALS:

- A. Product Certificates: For each type of roof edge flashing that is ANSI/SPRI/FM 4435/ES-1 tested.
- B. Evaluation Reports: For roof edge flashing, from an agency acceptable to authority having jurisdiction showing compliance with ANSI/SPRI/FM 4435/ES-1.
- C. Sample warranty.

1.5 QUALITY ASSURANCE:

- A. Applicable standards as referenced herein:
1. Aluminum Association (AA), "Aluminum Sheet Metal Work in Building Construction".
 2. American Architectural Manufacturers Association (AAMA).
 3. American Iron and Steel Institute (AISI), "Stainless Steel Data Manual".
 4. American National Standard Institute/Single Ply Roofing Institute (ANSI/SPRI), as referenced herein.
 5. ASTM International (ASTM).
 6. National Roofing Contractors Association (NRCA): "The NRCA Roofing Manual: Membrane Roof Systems-2011".
 7. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA), "Architectural Sheet Metal Manual," Seventh Edition - January, 2012.
 8. Society for Protective Coatings (SSPC), standards as referenced herein.

1.6 DELIVERY, STORAGE AND HANDLING:

- A. Store materials off ground, under cover. Protect from damage and deterioration.
- B. Handle materials to prevent damage to surfaces, edges and ends of sheet metal items. Damaged material shall be rejected and removed from site.

1.7 WARRANTIES:

- A. Warrant sheet metal flashing and trim work to be free of defects in materials and workmanship. Warranty period shall be two years beginning at Date of Substantial Completion.
- B. Special Warranty on Finishes: Manufacturer agrees to repair finish or replace sheet metal flashing and trim that shows evidence of deterioration of factory-applied finishes within specified warranty period.
1. Exposed Panel Finish: Deterioration includes, but is not limited to, the following:
 - a. Color fading more than 5 Delta units when tested in accordance with ASTM D2244.
 - b. Chalking in excess of a No. 8 rating when tested in accordance with ASTM D4214.
 - c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
 2. Finish Warranty Period: 20 years from date of Substantial Completion for fluoropolymer finishes.

- C. Coping and fascia warranty:
 - 1. Warrant materials to be free of defects in material and workmanship for five years. If, after inspection, manufacturer agrees that materials are defective, manufacturer shall, at their option, repair or replace them.
 - 2. Fabricator shall guarantee that a standard size roof edge system, when installed per roof manufacturer's instructions, will not blow off, leak, or cause membrane failure, even in wind conditions up to 120 mph, or the manufacturer shall replace or repair their materials.
 - 3. Warranty periods shall begin at Date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SHEET METAL MATERIALS:

- A. Aluminum: 0.063" thickness, 3003-H14 alloy, meeting ASTM B209-07.
 - 1. Fascias and coping: Minimum 0.050" thickness, fluoropolymer finish.
 - 2. Scuppers and conductor heads: Material thickness shall meet SMACNA Manual Table 1-5 requirements, minimum 0.063" thickness, fluoropolymer finish.
 - 3. Miscellaneous flashing and sheet metal: 0.040" thickness; mill finish.
- B. Roofing cement/mastic: As recommended by roof membrane manufacturer.
- C. Stainless steel: AISI Type 304 alloy, 2B finish.
 - 1. Scuppers: Minimum 24 gauge (0.025").
 - 2. Edge strips and hook strips: Minimum 20 gauge (0.0375"). Minimum 24 ga., AISI Type 302/304 alloy, 2B finish.
- D. Fasteners: Stainless steel.
 - 1. Nails: Flat head, needle point, not less than 12 ga. and of sufficient length to penetrate substrate 1" minimum.
 - 2. Expansion shields: Lead or bronze sleeves.
 - 3. Screws: Self-tapping type, with round heads.
 - 4. Bolts: Furnished complete with nuts and washers.
 - 5. Rivets: Round head, solid type.
 - 6. Blind clips and cleats: Same gauge as sheet metal.
- E. Silicone sealant for concealed joints:
 - 1. Acceptable products:
 - a. Dow Corning Corp., DOWSIL #795.
 - b. Pecora Corp., #895.
 - c. Tremco, Inc., an RPM Company, SpecTrem 2.
 - 2. Type: One-part silicone rubber; meeting ASTM C920-11, Type S, Grade NS, Class 25.
- F. Waterproof membrane subflashing:
 - 1. Acceptable products; subject to compliance with specified requirements:
 - a. Carlisle Coatings and Waterproofing, Inc., WIP 300HT.
 - b. Polyguard Products, Inc., Polyguard Deck Guard HT.
 - c. Grace Construction Products, Grace Ice & Water Shield HT (High-Temperature)
 - 2. Characteristics:
 - a. Type: Self-adhering rubberized asphalt sheet complying with ASTM D1970-11.
 - b. Thickness: Minimum 40 mils when tested in accord with ASTM D3767-03(2008), method A.
 - c. Tensile strength: 250 psi minimum when tested in accord with ASTM D412-06a.
 - d. Elongation: 250% when tested in accord with ASTM D412-06a, Die C Modified.
 - e. Provide primers, sealants and accessories required for a waterproof installation.

- G. Bituminous coating for separation of dissimilar materials: Cold-applied, asphalt roofing cement meeting ASTM D1187-97(2011), minimum 30 mils thickness.

2.2 FINISHES:

- A. Fluoropolymer coating finish:
1. Exposed aluminum flashing finish:
 - a. Two coat polyvinylidene fluoride (PVDF) 2-coat system that incorporates metal flakes in the color coat. A clear top coat protects the metal flakes and results in an outstanding metallic effect. shop-applied, baked-on, fluoropolymer coating system based on minimum 70% Arkema Group, Kynar 500 or Solvay Solexis, Inc., Hylar 5000 resin (Polyvinylidene fluoride, PVDF), formulated by a licensed manufacturer and applied by manufacturer's approved applicator to meet AAMA 2605-05.
 - b. Color: To be selected by Architect.
 2. Finish on unexposed surfaces: Mill finish.
 3. Work to receive fluoropolymer coating includes copings, fascias, and sheet metal flashing and trim exposed to view.

2.3 ALUMINUM COPINGS:

- A. Copings shall not negatively impact specified roofing system warranty.
- B. Acceptable manufacturers:
1. W. P. Hickman Co.
 2. Innovative Metals Company, Inc. (IMETCO).
 3. Metal-Era, Inc.
- C. Characteristics:
1. Material: Formed aluminum alloy, smooth surface. Minimum thickness as follows:
 - a. Up to 4" face: Use 0.040".
 - b. From 4" to 8" face: Use 0.050".
 - c. From 8" to 10" face: Use 0.063".
 - d. Over 10" face: Use 0.080".
 2. Finish: Fluoropolymer coating, as specified herein.
 3. Face height: As indicated on drawings.
 4. Lengths: 10'-0" minimum.
 5. Joints: Splice plates, concealed, in accord with manufacturer's product data.
- D. Accessories:
1. Splice plates: 0.050" thickness aluminum sheet, 6" minimum width, for concealed installation. Finish shall match copings.
 2. Anchor plate: Hot dip galvanized steel of manufacturer's standard design.
 3. Prefabricated sections: Factory-assembled, mitered, welded corners, to match copings in design and finish.

2.4 FLASHING REGLET SYSTEM:

- A. Acceptable products:
1. Fry Reglet Corp., Springlok, SM Type.
 2. W.P. Hickman, Surface-Mount Counter Flashing Type.
 3. Metal-Era Roof edge Systems, CWF2-500 Surface Mount Type.
- B. Characteristics:
1. Material for surface-mounted reglets: Aluminum alloy reglet and counterflashing; counterflashing minimum 0.032" thickness.
 2. Finish: Factory applied fluoropolymer coating finish, colors as selected by Architect.
 3. Accessories: Prefabricated interior and exterior corners and splice plates.
 4. Reglet cover: Reglet for cast-in-place concrete shall have factory-installed temporary cover to prevent migration of concrete into reglet.

2.5 DOWNSPOUT BOOTS:

- A. Acceptable manufacturers:
 - 1. Barry Pattern & Foundry Company, Inc.
 - 2. Downspoutboots.com, a division of J.R. Hoe and sons.
 - 3. Jay R. Smith Mfg. Co.
 - 4. Piedmont Pipe manufacturing.
- B. Characteristics:
 - 1. Material: One of the following:
 - a. Aluminum:
 - 1) Cast aluminum shall be melted from the highest grade 319 alloy.
 - 2) Extruded aluminum shall be made from 6063-T5 alloy base and heat treated.
 - b. Cast Iron: Castings shall be of gray cast iron, conforming to A.S.T.M., A-48-70, U.S. Q&QI-652c or A.A.S.H.O. M-105-621 specifications as required shall be machineable.
 - c. Type 304 stainless steel.
 - 2. Type: Coordinate configuration, size and length with downspouts and below grade drain pipe system.
 - 3. Finish: Powder coat finish in color selected by Architect from manufacturer's full range.

2.6 SHEET METAL FABRICATION:

- A. Fabricate sheet metal work in accord with approved shop drawings and applicable standards. Form sheet metal work with clear, sharp and uniform arrises. Hem exposed edges.
- B. In aluminum sheets less than 0.040" thick, make joints using flatlock seams, 3/4" in width. Fill seams with exterior sealant. Make joints in thicker sheets using seaming or by Tungsten Arc Welding (TIG) or Gas Metal Arc Welding (MIG) processes, using appropriate filler alloy.
- C. Provide linear sheet metal items in 10'-0" to 12'-0" sections, except as otherwise noted. Form flashing using single pieces for the full width. Provide shop-fabricated, one-piece corners and transition pieces, with maximum 2'-0" long legs.
- D. Make riveted joints using solid shank rivets or pop rivets as applicable. Pop rivets shall be closed end type.

PART 3 - EXECUTION

3.1 SHEET METAL INSTALLATION:

- A. Install work in accord with approved shop drawings and applicable standards. Sheet metal items shall be true to line, without buckling, creasing, warp or wind in finished surfaces.
- B. Coordinate flashing at roof surfaces with roofing work to provide weathertight condition at roof terminations.
- C. Perform field joining of lengths as specified for shop fabrication.
- D. Isolate dissimilar materials to prevent electrolysis. Separate using bituminous coating.
- E. Seaming: Form seams in direction of flow. Aluminum seams shall be filled with exterior sealant. Lap seams occurring in members sloping 45° or more than 4", minimum; bed in flashing cement.
- F. Secure sheet metal items using continuous cleats, clips and fasteners as indicated. Perform no exposed face fastening.

- G. Fastening:
1. Nails: Confine to one edge only of flashing 1'-0" or less in width. Space nails at 4" o. c., maximum. Provide neoprene washers for nails.
 2. Cleats: Continuous, formed to profile of item being secured.
 3. Clips: Minimum 2" wide by 3" long, formed to profile of item being secured. Space at 2'-0" o. c., maximum.
- H. Joints:
1. Form joints in linear sheet metal to allow for 1/2" minimum expansion at 12'-0" o. c., maximum, and maximum 2'-0" from corners.
 2. Form plates to profile of sheet metal item.
 3. Install 1'-0" wide backup plate centered under joint. Set sheet metal over backup plate in two beads of specified silicone sealant, 1/4" in diameter, minimum.
 4. For units with top width of 12" and wider, install 6" cover plate centered over joint. Set in two beads of specified silicone sealant, 1/4" in diameter, minimum.
 5. Mate components for positive seal. Do not allow sealant to migrate onto exposed surfaces.
- I. Where sheet metal is indicated as flashing above and below heads of doors, windows and other penetrations, extend flashing minimum 8" beyond opening, each side. Turn ends up minimum 2" to form end dams and to ensure drainage through weeps and not into cavity.
- J. Scuppers and conductor heads:
1. Construct with welded joints, lapped 1" minimum, in direction of flow.
 2. Install through-wall spillout scuppers in accord with SMACNA Manual, Figure 1-26, with Detail 2 Alternate connection to conductor heads, and Figure 1-27A. Seal perimeters.
 2. Install overflow scuppers in accord with SMACNA Manual, Figure 1-30. Seal perimeters.
- K. Roof penetration flashing: Refer to roof membrane system section.

3.2 COPING INSTALLATION:

- A. Install prefabricated copings in accord with manufacturer's product data and ANSI/SPRI ES-1, true to line.
- B. Install waterproof membrane subflashing under copings, secured under backup plates and continuous cleats.
1. Install membrane subflashing fully adhered to substrates in accord with manufacturer's product data, except where more stringent requirements are specified herein.
 2. If required, prime surfaces to receive membrane materials. Allow primer to dry until tack-free. Prime only area which can be covered with sheet membrane during work period. Reprime surfaces which are not covered within 24 hours of primer application.
 3. Install membrane materials with side and end laps recommended by product data. Begin installation at low points, lapping succeeding sheets to shed water.
 4. Membrane applications shall be fully adhered, smooth, straight and free of blisters, buckles, fishmouths and wrinkles affecting the complete adherence of the membrane. Patch and repair defective work in accord with manufacturer's product data. Areas which exhibit defective areas or generally poor or improper workmanship shall be removed and replaced.
 5. Double membrane at changes in plane by application of a centered membrane strip. Cover strip completely with full width sheet.
 6. Seal around protrusions and at terminations in accord with product data.
 7. Repair punctures and tears in membrane by patching with membrane material prior to protection board installation. Trowel-apply roofing cement at exposed edges of patch.
- C. Install anchor plate at 5'-0" o. c. maximum under copings. Install concealed splice plates at intersections in accord with manufacturer's product data.

- D. Install copings over anchor plates and splice plates, with minimum 3/8" wide joints over splice plate intersections. Set copings over splice plates in full bed of silicone sealant or extruded butyl tape, 1/2" from intersection edges.
- E. Make weathertight fit, allowing for expansion and contraction as recommended by manufacturer's product data.
- F. Attach materials using aluminum or stainless steel fasteners. Exposed fasteners shall match metal in finish.

3.3 REGLET INSTALLATION:

- A. Install reglets as directed by manufacturer, level and true to line. Verify that flashing occurs at or above reglet locations.
 - 1. Surface-mounted and stucco reglets: Install reglets as walls are built.
 - 2. Install with top of reglet minimum of 8" above high point of cant strip.
- B. Terminate reglet 2" from each side of expansion and control joints in substrates to which surface-applied reglets are installed. Provide 1'-0" wide cover plate of reglet material, overlapping adjacent reglet lengths 4". Attach cover plates to provide discontinuous joints.
- C. Provide factory-fabricated corners at changes in direction.
- D. Following installation of roofing, install counterflashing by snapping into reglet in accord with manufacturer's product data. Overlap adjacent lengths 6", minimum, to allow for expansion and contraction. Caulk top edge of reglet using exterior silicone sealant as specified in Section 07 9200 - Joint Sealants.

END OF SECTION

SECTION 07 8400 - FIRESTOPPING

PART 1 - GENERAL

1.1 SUMMARY:

- A. Related work:
 - 1. Concrete.
 - 2. Concrete unit masonry.
 - 3. Structural steel.
 - 4. Metal decking.
 - 5. Metal fabrications.
 - 6. Thermal insulation.
 - 7. Fireproofing.
 - 8. Joint sealants.
 - 9. Curtain/window walls.
 - 10. Gypsum board.
 - 11. Fire protection specialties.
 - 12. Elevator equipment.
 - 13. Mechanical.
 - 14. Plumbing.
 - 15. Electrical.

1.2 SYSTEM PERFORMANCE REQUIREMENTS:

- A. Firestopping systems shall provide resistance to spread of fire, and passage of smoke and other gases according to requirements indicated, including but not limited to the following:
 - 1. Firestop penetrations passing through fire resistance rated wall and floor assemblies and other locations as indicated on drawings.
 - 2. Penetration firestopping systems shall have been tested and approved by third party testing agency.
 - 3. Through-penetration firestop systems and devices shall resist spread of fire, and passage of smoke and other gases according to requirements indicated, including but not limited to the following:
 - a. F - rating shall equal or exceed the rating of the fire-resistive construction assembly through which the penetration is made, as determined by ASTM E814-11a, but shall be not less than 1-hour.
 - b. T - rating, in addition to F-rating, at penetrations located outside of a wall cavity, shall equal fire-resistive rating of floor construction, as determined by ASTM E814-11a, but shall be not less than 1-hour.
 - c. L - rating: In addition to F and T ratings, firestopping shall have an L - rating, as determined by UL 1479, where indicated by code.
 - d. W - rating: In addition to F, T and L ratings, firestopping shall have W - rating, as determined by UL 1479, where indicated.
 - 4. Perimeter fire containment systems (Exterior curtainwall/floor intersection): Interior perimeter joint systems with fire-resistance ratings indicated, as determined by ASTM E2307-10, but not less than fire-resistance rating of the floor construction.
 - 5. Fire-resistive joints shall have fire-resistance ratings indicated, as determined by UL 2079, but not less than fire-resistance rating of construction in which the joint occurs.
 - 6. Firestop systems using cementitious fill materials shall not be permitted.
 - 7. Systems shall be free of asbestos and volatile organic compounds (VOCs).
 - 8. Where there is no specific third party tested and classified firestop system available for a particular firestop configurations, obtain from firestop manufacturer, an Engineering Judgement (EJ) or Equivalent Fire Resistance Rated Assembly (EFFRA).
 - 9. Systems used within or adjacent to occupied spaces shall be free of volatile solvents, noxious fumes and strong odors.

1.3 ACTION SUBMITTALS:

- A. Shop drawings: Submit detailed drawings of each type and size penetration through fire-rated construction, indicating materials, dimensions, assembly construction and rating. Indicate through-penetration firestop system design listings, including illustrations from a qualified testing and inspection agency for each type penetration.
- B. Product data: Submit product data and installation instructions for each type of installation. Include installation details and test reports indicating that firestopping materials, systems and devices meet specified requirements and design criteria. Indicate Classification marking of qualified testing and inspection agency.

1.4 INFORMATIONAL SUBMITTALS:

- A. Certifications:
 - 1. Submit written certification that firestop materials are asbestos free and that materials comply with local regulations.
 - 2. Submit written certification that firestop materials comply with local regulations controlling use of volatile organic compounds (VOC's) and are non-toxic to building occupants.
- B. Product Test reports: Certified copies of test reports (conclusions and summary only) from approved independent testing laboratories showing compliance with the Contract Documents and including current system number per UL Listing for each type of penetration firestopping system to be utilized on the project.
- C. Inspection test reports: Submit copies of inspection test reports, prepared by an independent testing agency, for penetration firestop systems and perimeter fire barriers in accordance with report procedures as contained within ASTM E2174 and ASTM E2393 showing inspection results and remedial action taken, if any.
- D. Building Department Acceptance: If applicable submit a copy of the Building Department acceptance sheet for each penetration firestop system submitted for each specific condition on Project.
- E. Research/Evaluation Reports: For each type of fire-resistive joint system. Evidence of penetration firestop systems' compliance with ICBO ES AC308, from the ICBO Evaluation Service.
- F. Installer Certificates: From Installer indicating that penetration firestopping systems have been installed in compliance with requirements and manufacturer's written instructions.

1.5 QUALITY ASSURANCE:

- A. Applicable standards; standards of the following, as referenced herein:
 - 1. ASTM International (ASTM).
 - 2. National Fire Protection Association (NFPA).
 - 3. Underwriters Laboratories, Inc. (UL).
- B. Fire-test-response characteristics: Provide firestopping system design listing by a testing and inspection agency in accord with the specified UL standards.
- C. Acceptable installer shall comply with one or more of the following:
 - 1. Installer Qualifications: A firm that has been approved by FM Global according to FM Global 4991, "Approval of Firestop Contractors," or been evaluated by UL and found to comply with UL's "Qualified Firestop Contractor Program Requirements."
 - 2. Licensed by state or local authority, where applicable.
 - 3. Successfully completed not less than 5 comparable scale projects.
- D. Single source responsibility: Obtain firestop systems for each kind of penetration and construction condition indicated from a single primary firestop systems manufacturer.
 - 1. Materials from different manufacturer than allowed by tested and listed system shall not be intermixed in the same firestop system or opening.

2. Install tested and listed firestop systems before installing an Engineering Judgement or Equivalent Fire Resistance Rated Assembly (EFFRA).

1.6 DELIVERY STORAGE AND HANDLING:

- A. Deliver firestopping materials in original, unopened containers or packages with intact and legible manufacturers' labels identifying product and manufacturer.
- B. Store and handle firestopping materials in accord with manufacturer's product data.

1.7 JOB CONDITIONS:

- A. Coordinate firestopping installation with other work requiring penetrations through fire-resistive construction. Install penetrating elements prior to installation of firestopping systems or devices.
- B. Secure inspection and approval of firestopping work by building officials prior to concealment.
- C. Support penetrating elements independently of firestopping systems or devices.
- D. Do not cover up firestopping installations until Owner's inspection agency or Authorities Having Jurisdiction have examined each installation.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL:

- A. VOC Content: Penetration firestopping sealants and sealant primers shall comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
 1. Sealants: 250 g/L.
 2. Sealant Primers for Nonporous Substrates: 250 g/L.
 3. Sealant Primers for Porous Substrates: 775 g/L.

2.2 THROUGH-PENETRATION FIRESTOP SYSTEMS:

- A. Acceptable manufacturers; subject to compliance with specified requirements:
 1. Hilti USA.
 2. 3M Fire Protection Products.
 3. Nelson Firestop Products.
 4. The RectorSeal Corp.
 5. Specified Technologies, Inc. (STI).
 6. Tremco, Inc.
- B. System description: Field-constructed firestopping for penetrations through walls and floors composed of specified materials and accessories assembled in accord with Through-Penetration Firestopping System Numbers, listed in UL Building Materials Directory, current Edition, and tested in accord with ASTM E814-11a.
- C. Materials: UL Classified for use in through-penetration firestop systems.
 1. Firestop sealant: Single-component, elastomeric silicone or endothermic latex sealant compound; self-adhering, flexible and watertight; non-sag and self-leveling types as required.
 2. Firestop foam: Two-part, room temperature vulcanizing, silicone elastomer, non-combustible foam void seal.
 3. Intumescent sealants and putties: Single-component, synthetic, organic/inorganic intumescent elastomers.
 4. Intumescent wrap strips: One-part, organic/inorganic, intumescent elastomeric sheet; aluminum foil-faced one side.

5. Intumescent composite sheets: Composite sheets composed of organic/inorganic intumescent elastomeric core bonded on one side to 28 ga. galvanized steel sheet and other side reinforced with steel wire mesh, covered with aluminum foil.
 6. Mineral wool or ceramic fiber safing: Non-combustible fiber tested in accord with ASTM E136-12, with melting point in excess of 2000 degrees F.; flame spread of 15 maximum and 0 smoke development when tested in accord with ASTM E84-12c. Thickness and density shall be as required by Through-Penetration Firestop System designs.
- D. Accessories:
1. Primers, adhesives and backer rods: As required by manufacturer's product data and system designs.
 2. Forming, damming and packing materials: Types as indicated in Through-Penetration Firestop Systems.
 3. Restricting collars: Manufacturer's standard design as required for firestop system.
 4. Fasteners, anchor clips, sleeves, clamps, spacers, ties, cover plates and miscellaneous accessories: Provide as required by manufacturer's product data and in accord with Through-Penetration Firestop System designs.

2.3 THROUGH-PENETRATION FIRESTOP DEVICES:

- A. Acceptable manufacturers; subject to compliance with specified requirements:
1. Hilti USA.
 2. 3M Fire Protection Products.
 3. Nelson Firestop Products.
 4. The RectorSeal Corp.
 5. Specified Technologies, Inc. (STI).
 6. Tremco, Inc.
- B. Types: Factory-assembled, self-contained firestopping devices for penetrations through walls and floors; UL Classified for Through-Penetration Firestop Devices as listed in UL Building Materials Directory, current Edition, and tested in accord with ASTM E814-11a.
- C. Accessories: Provide sealants, adhesives, fasteners, sleeves, clamps, spacers, anchor clips, ties and accessories in accord with manufacturer's product data and as required for complete installation.

2.4 FIRESTOP SEALANTS:

- A. Acceptable products; subject to compliance with specified requirements:
1. Hilti USA, CP 601S Firestop Sealant.
 2. Nelson Firestop Products, CLK.
 3. 3M Fire Protection Products, Fire Barrier Silicone Sealant 2000 N/S.
 4. The RectorSeal Corp., FlameSafe FS 4000 Silicone Sealant.
 5. The RectorSeal Corp., Metacaulk 835+.
 6. Specified Technologies, Inc. (STI), SpecSeal Pen 300 Silicone Joint Sealant.
 7. Tremco, Inc., Fyre-Sil.
- B. Characteristics: Single-component, self-adhering, flexible, watertight, elastomeric silicone sealant compound; UL Classified. Provide self-leveling type for horizontal applications, non-sag type for all other applications.

2.5 SAFING:

- A. Acceptable products; subject to compliance with specified requirements:
1. Thermal Ceramics, Cerablanket F.S.
 2. Thermafiber Inc., Thermafiber Safing Insulation.
- B. Characteristics:
1. Material: Semi-rigid mineral fiber insulation, meeting ASTM C665-12, Type 1.
 2. Density: 4.0 pcf.

3. Thickness: As indicated.
 4. Facing: Unfaced.
 5. Fire resistance properties:
 - a. Melting point: Minimum of 2000°F. when tested in accord with ASTM C24-09.
 - b. Non-combustible: As defined by ASTM E136-12 and NFPA.
 - c. Fire hazard characteristics: Maximum flame spread of 15 and smoke development of 5 when tested in accord with ASTM E84-12c (unfaced).
 6. Fire safing: Tested in accord with ASTM E119-12a without deterioration for minimum of five hours in a slab edge/spandrel configuration.
- C. Accessories:
1. Clips: Insulation manufacturer's standard galvanized steel impaling clips for attachment of safing.
 2. Sealant: Manufacturer's tested sealant material for foil-faced smoke seal.

2.6 INTUMESCENT PUTTY PADS:

- A. Approved Products:
1. Hilti, Inc. CP617 and CP617C Firestop Putty Pad.
 2. Nelson Firestop Products, Inc. FSP.
 3. Specified Technologies, Inc. SpecSeal Putty Pads.
 4. 3M, 3M Fire Barrier Moldable Putty.
 5. Tremco, Inc. TremStop Putty.
- B. Characteristics: Non-hardening, intumescent compound designed to seal thru-penetrations in release lined pad form; faced on both sides with poly liner for electrical boxes.

PART 3 - EXECUTION

3.1 PRE-INSTALLATION REQUIREMENTS:

- A. Pre-installation meeting: Prior to beginning firestopping work, a pre-installation meeting shall be held to review work to be accomplished.
1. Contractor, Architect, firestopping system manufacturers' representatives, installer and other subcontractors whose work involves firestopping shall be present.
 2. Contractor shall notify all parties at least seven days prior to time for meeting.
 3. Contractor shall record minutes of meeting and distribute to attending parties.
- B. Job mock-ups:
1. Install one of each type firestopping assembly for review by Architect prior to commencement of firestopping work. Notify Architect at least 36 hours in advance for observation of mock-up installations, including check for objectionable or noxious fumes or odors. Should mock-ups be unacceptable, prepare additional mock-ups until acceptable to Architect.
 2. Following Architect's review, identify and preserve mock-ups as a standard of quality for remaining firestopping work. Acceptable mock-ups may remain as part of the finished work.

3.2 EXAMINATION:

- A. Examine areas to receive firestopping materials prior to beginning work. Verify that opening areas and dimensions for penetrations to receive firestopping systems and devices do not exceed design requirements.
- B. Remove projections interfering with installation. Prepare surfaces in accord with manufacturer's product data and UL Through-Penetration Firestop Devices Numbers.

3.3 PREPARATION:

- A. Priming: Prime substrates where recommended by firestopping manufacturer using that manufacturer's recommended products and methods. Confine primers to areas of bond. Do not allow spillage and migration onto exposed surfaces.
- B. Masking tape: Use masking tape to prevent firestopping from contacting adjoining surfaces that will remain exposed upon completion of the Work. Remove tape as soon as it is possible to do so without disturbing the firestopping seal with substrates.

3.4 INSTALLATION:

- A. General:
 - 1. Comply with manufacturer's product data and UL Classified for Through-Penetration Firestop Devices Numbers.
 - 2. Install firestopping materials fitted to adjacent construction to fill voids.
 - 3. Firestop penetrations through fire-rated walls, partitions, floors and floor/ceiling assemblies with tested assemblies in accord with UL 1479 or with a through-penetration firestop system or device when tested in accord with ASTM E814-11a.
 - 4. Firestopping shall comply with code requirements.
- B. Fire and smoke barrier identification:
 - 1. Fire walls, fire barriers, fire partitions, smoke barriers and smoke partitions or any other rated wall required to have protected openings shall be effectively and permanently identified with signs or stenciling in a manner acceptable to the Authority having Jurisdiction.
 - 2. Such identification shall be above any decorative ceiling and in concealed spaces, and near the top of the wall or barrier in unfinished spaces.
 - 3. Such identification shall be letters a minimum of 2" (51 mm) high on a contrasting background, spaced at 12'-0" o.c. maximum, with a minimum of one per wall or barrier. Comply with code requirements.
 - 4. Suggested wording for fire and smoke barriers: "_____ HOUR FIRE AND SMOKE BARRIER – PROTECT ALL OPENINGS."
- C. Through-penetration firestop systems and devices:
 - 1. Install at penetrations through fire-rated floor and wall construction, including partitions and floor/ceiling assemblies, in accord with manufacturer's product data and UL System Numbers. Provide materials and accessories as required.
 - 2. Install intumescent type firestop systems where plastic piping, cable, conduit and other combustible items, including insulated metal pipes, penetrate fire-rated construction.
 - 3. At Contractor's option, through-penetration firestop devices of similar function may be installed in lieu of firestop systems.
 - 4. Do not remove forming materials unless specified in system designs.
- D. Firestop sealant: Seal perimeters, voids and joints of fire-rated walls and partitions, including abutment of floor and roof or ceiling structure, and flutes of metal decking.
 - 1. If required by UL Design, install mineral wool or ceramic fiber in cavities, packed full and tight with allowance for sealant installation.
 - 2. Seal both faces of walls and partitions with firestop sealant. Tool sealant flush with adjacent finish.
 - 3. In accord with UL Fire Resistance Directory Designs, packed concrete and masonry joints shall be sealed using firestop sealant or using sealant as specified in Section 07 9200 - Joint Sealants.
- E. Mineral fiber safing:
 - 1. Install safing in cavities of penetrations through non-rated floor and wall construction, including spaces around piping, conduits, cables and duct penetrations.
 - 2. Install safing in voids and joints of non-rated walls and partitions abutting metal decking of floor and roof structures. Pack flutes of metal decking solid with safing material.

3. Safing shall be installed at joints and penetrations in non-rated construction not exposed to view and concealed in finish work. Secure safing by compressing into voids or joints and using manufacturer's standard clips or closure plates as required.

- F. Seal voids and joints of non-rated walls and partitions abutting concrete floor and roof construction using sealant as specified in other sections.

3.5 FIELD QUALITY CONTROL:

- A. Inspection: Independent inspection agency employed and paid by Owner, will examine penetration firestopping in accord with ASTM E2174-10a and ASTM E2393-10a. Inspection agency will examine firestopping and will determine, in general, that firestopping has been installed in compliance with tested and listed firestop system, and that installation process conforms to FM 4991 - Standard for Approval of Firestop Contractors or UL Qualified Firestop Contractor Program.
- B. Inspector will advise contractor of deficiencies noted within one working day.
- C. Do not proceed to enclose firestopping with other construction until inspection agency has verified firestop installation complies with requirements of Contract Documents.
- D. Where deficiencies are found, repair or replace firestopping so that it complies with requirements of tested and listed system design.

3.6 CLEANING:

- A. Clean off excess fill materials and sealants adjacent to openings and joints as work progresses. Use methods and cleaning materials approved by manufacturers of firestopping products and or assemblies in which openings and joints occur.
- B. Protect firestopping during and after curing period from contact with contaminating substances.

END OF SECTION

SECTION 07 9200 - JOINT SEALANTS

PART 1 - GENERAL

1.1 SUMMARY:

- A. Related work specified elsewhere:
 - 1. Window framing internal sealants.
 - 2. Glazing sealants.
 - 3. Roofing and flashing sealants.
 - 4. Firestopping.
- B. Definitions:
 - 1. Joint sealant:
 - a. A weatherproof elastomer used in filling and sealing joints, having properties of adhesion, cohesion, extensibility under tension, compressibility and recovery; designed to make joints air and watertight.
 - b. Material is designed generally for application in exterior joints and for joints subject to movement.
 - 2. Joint sealant compound:
 - a. A material used in filling joints and seams, having properties of adhesion and cohesion; not required to have extensibility and recovery properties.
 - b. Material is designed generally for application in interior joints not subject to movement.
 - 3. Caulk: The process of filling joints, without regard to type of material.
 - 4. Joint failure: A caulked joint exhibiting one or more of the following characteristics:
 - a. Air and/or water leakage.
 - b. Migration and/or reversion.
 - c. Loss of adhesion.
 - d. Loss of cohesion.
 - e. Failure to cure.
 - f. Discoloration.
 - g. Staining of adjacent work.
 - h. Development of bubbles, air pockets or voids.

1.2 ACTION SUBMITTALS:

- A. Product data: Submit manufacturer's product description, indicating conformance with specified requirements and installation instructions for each type of sealant. Indicate preparation and priming requirements for each substrate condition.
- B. Color samples:
 - 1. Samples for initial selection: Samples shall be actual materials or literature depicting actual colors of standard color materials showing full range of colors available for each product exposed to view.
 - 2. Samples for verification: For each kind and color of joint sealant required, provide samples with joint sealants in 1/2" wide joints formed between two 6" long strips of material matching appearance of exposed surfaces adjacent to joint sealants.
 - 3. Submit samples of custom color sealant materials matching color sample selected by Architect.
- C. Adhesion compatibility test results: Submit a letter from sealant manufacturer indicating adhesion and compatibility testing has been performed and that materials are compatible and that adhesion is acceptable. Indicate requirements for primers or special preparation.
- D. Substrate staining test results: Submit a letter from sealant manufacturer indicating that substrate stain testing has been performed on actual samples of substrates indicated to receive joint sealant and that sealant was found to be non-staining to substrate. Indicate requirements for primers or special preparation to meet non-staining requirements.

- E. Joint sealant schedule: Include the following information:
 - 1. Joint sealant applications, joint locations, and designations.
 - 2. Joint sealant manufacturers and product names.
 - 3. Joint sealant formulations.
 - 4. Joint sealant colors.

1.3 QUALITY ASSURANCE:

- A. Applicable standards as referenced herein:
 - 1. ASTM International (ASTM).
- B. Adhesion compatibility tests: Perform tests on actual samples of aluminum framing system, storefront, precast concrete, stone components, to determine that materials are compatible and that adhesion is acceptable. Identify requirements for primers or special preparation.
 - 1. Test structural sealants in accord with ASTM C1135.
- C. Substrate staining test results: Perform test on actual samples of granite veneer to receive joint sealant to determine that sealant is non-staining to substrate. Identify requirements for primers or special preparation to meet non-staining requirements.
 - 1. Test porous substances in accord with ASTM C1248.
 - 2. Test non-porous substrates in accord with ASTM D2203.
- D. VOC content of interior sealants: Sealants and sealant primers used inside the weatherproofing system shall comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
 - 1. Architectural sealants: 250 g/L.
 - 2. Sealant primers for nonporous substrates: 250 g/L.
 - 3. Sealant primers for porous substrates: 775 g/L.
- E. Architect reserves the right to reject work not in conformance with selected colors, based upon verification samples.

1.4 PROJECT/SITE CONDITIONS:

- A. Weather conditions:
 - 1. Install no materials under adverse weather conditions or when temperatures are below or above those recommended by manufacturer's product data or when substrate moisture content is above manufacturer's recommended level.
 - 2. Proceed with work only when forecasted weather conditions are favorable for joint cure and development of high early bond strength.
 - 3. Wherever joint width is affected by ambient temperature variations, install materials only when temperatures are in lower third of manufacturer's recommended installation temperature range.
- B. Protection of adjacent surfaces:
 - 1. Protect by applying masking material or manipulating application equipment to keep materials in joint. If masking materials are used, allow no tape to touch cleaned surfaces to receive sealant. Remove tape immediately after sealant application, before surface skin begins to form.
 - 2. Remove misapplied materials from surfaces by using solvents and methods recommended by manufacturer.
 - 3. At surfaces from which materials have been removed, restore to original condition and appearance.

1.5 WARRANTIES:

- A. Installer's warranty: Warrant work to be watertight and free from defects in materials and workmanship, including joint failure, for a period of two years.
- B. Exterior silicone sealant material warranty: Warrant exterior silicone sealants to be free from defects in materials and to provide structural adhesion, watertight weatherseal and non-staining of adjacent materials for a period of twenty years.

- C. Exterior polyurethane sealant material warranty: Warrant exterior polyurethane sealants to be free from defects in materials and to provide a watertight weatherseal for a period of five (5) years.
- D. Warranties shall begin at Date of Substantial Completion.

PART 2 - PRODUCTS

2.1 JOINT SEALANTS, GENERAL:

- A. Compatibility: Provide joint sealants, backings, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.
- B. VOC Content: Sealants and sealant primers shall comply with the following:
 - 1. Architectural sealants shall have a VOC content of 250 g/L or less.
 - 2. Sealants and sealant primers for nonporous substrates shall have a VOC content of 250 g/L or less.
 - 3. Sealants and sealant primers for porous substrates shall have a VOC content of 775 g/L or less.
- C. Liquid-Applied Joint Sealants: Comply with ASTM C920 and other requirements indicated for each liquid-applied joint sealant specified, including those referencing ASTM C920 classifications for type, grade, class, and uses related to exposure and joint substrates.
- D. Stain-Test-Response Characteristics: Where sealants are specified to be nonstaining to porous substrates, provide products that have undergone testing according to ASTM C1248 and have not stained porous joint substrates indicated for Project.
- E. Suitability for Contact with Food: Where sealants are indicated for joints that will come in repeated contact with food, provide products that comply with 21 CFR 177.2600.
- F. Colors of Exposed Joint Sealants: As selected by Architect from manufacturer's full range.

2.2 SILICONE SEALANTS:

- A. Low modulus silicone sealant at cement plaster, masonry to masonry, concrete to concrete and other exterior porous substrates:
 - 1. Acceptable products; subject to compliance with specified requirements:
 - a. Dow Corning Corp., DOWSIL #790.
 - b. Momentive Performance Materials, Inc., GE Silpruf LM SCS2700.
 - c. Pecora Corp., #890NST.
 - d. Tremco, Inc., an RPM Company, SpecTrem 1.
 - 2. Type: One-part, low modulus silicone rubber; meeting ASTM C920, Type S, Grade NS, Class 50, for use NT.
 - 3. Colors: Standard colors as selected by Architect.
- B. Medium modulus silicone sealant at metal to metal framing, and other exterior non-porous substrates in aluminum framing; excluding dry joint system in metal panels:
 - 1. Acceptable products; subject to compliance with specified requirements:
 - a. Dow Corning Corp., DOWSIL #795.
 - b. Momentive Performance Materials, Inc., GE Silpruf SCS2000.
 - c. Pecora Corp., #895NST.
 - d. Tremco, Inc., an RPM Company, SpecTrem 2.
 - 2. Type: One-part silicone rubber; meeting ASTM C920, Type S, Grade NS, Class 50, for use NT.
 - 3. Colors: Standard colors as selected by Architect.
- C. Nonstaining Joint Sealants: No staining of substrates when tested according to ASTM C1248.

2.3 SILICONE BATH SEALANT FOR WET AREAS:

- A. Acceptable products:
 - 1. Dow Corning Corp., DOWSIL 786 Mildew-Resistant Silicone Sealant.
 - 2. Franklin International, Titebond Kitchen & Bath Sealant.
 - 3. Momentive Performance Materials, Inc., GE Sanitary SCS1700.
 - 4. Pecora Corp., #898NST Silicone Sanitary Sealant.
- B. Characteristics:
 - 1. Type: One-part silicone rubber, mildew- and stain-resistant, acid-curing silicone sealant; meeting ASTM C920, Type S, Grade NS, Class 25, for use NT.
 - 2. Color: Clear, white or off-white, as selected by Architect.

2.4 TWO-PART POLYURETHANE SEALANT FOR EXTERIOR HORIZONTAL TRAFFIC-BEARING PAVEMENTS:

- A. Acceptable products:
 - 1. MBCC Group (Master Builders Construction Chemicals), MasterSeal SL 2.
 - 2. Pecora Corp., Urexpan NR-200.
 - 3. Tremco, Inc., an RPM Company, 45 SSL.
 - 4. Lyntal International, Iso-Flex 880 Series.
- B. Characteristics:
 - 1. Type: Two-component polyurethane sealant for horizontal traffic-bearing surfaces meeting ASTM C920, Type M, Grade P or NS, minimum Class 25, for use T; self-leveling for flat surfaces and non-sag for sloped surfaces.
 - 2. Colors: Standard colors as selected by Architect.

2.5 INTERIOR PEDESTRIAN TRAFFIC HORIZONTAL SEALANT:

- A. Acceptable products; Heavy-duty sealant for horizontal traffic-bearing joints:
 - 1. Pecora Corp., Dynatred.
 - 2. Sika Corp., Sikaflex 2cSL.
 - 3. Tremco, Inc., Vulkem 116.
- B. Characteristics:
 - 1. Type: Two-part polyurethane, chemical-curing, Shore A, 40 minimum hardness meeting C920, Type M, Grade P or NS, minimum Class 25, Uses T, M, A, O.
 - 2. Colors: Standard colors as selected by Architect.

2.6 PAINTABLE ACRYLIC-LATEX JOINT SEALANT:

- A. Acceptable products:
 - 1. Bostik, Chem-Calk 600.
 - 2. Franklin International, Titebond Painters Caulk.
 - 3. Momentive Performance Materials, Inc., GE RCS20.
 - 4. Pecora Corp., AC-20 Acrylic Latex.
 - 5. Tremco, Inc., an RPM Company, Tremflex 834.
- B. Characteristics: Flexible, paintable, non-staining, non-bleeding acrylic latex or siliconized acrylic emulsion, meeting ASTM C834, Type OP, Grade NF.

2.7 ONE-PART, NON-SAG POLYURETHANE SEALANT:

- A. Acceptable products:
 - 1. MBCC Group (Master Builders Construction Chemicals), MasterSeal NP-1.
 - 2. Pecora Corp., Dynatrol I-XL.
 - 3. Tremco, Inc., an RPM Company, Vulkem 116.
 - 4. Tremco, Inc., an RPM Company, Dymonic.

- B. Characteristics:
 - 1. Type: One-part, non-sag polyurethane-based sealant; meeting ASTM C920, Type S, Grade NS, minimum Class 25.
 - 2. Colors: Standard colors as selected by Architect.

2.8 SOLVENT-RELEASE-CURING ACRYLIC SEALANT:

- A. Acceptable products:
 - 1. Franklin International, Titebond Painters Plus Caulk.
 - 2. Schnee-Morehead, Inc., Acryl-R Acrylic Sealant.
 - 3. Tremco, Inc., an RPM Company, Mono 555.
- B. Characteristics:
 - 1. Type: One-part, acrylic polymer sealant, meeting ASTM C1311.
 - 2. Colors: Standard colors as selected by Architect.

2.9 ACOUSTICAL SEALANTS:

- A. Performance requirements:
 - 1. Provide acoustical joint-sealant products that effectively reduce airborne sound transmission through perimeter joints and openings in building construction, as demonstrated by testing representative assemblies according to ASTM E90.
 - 2. Sealant shall have a VOC content of 250 g/L or less.
- B. Acoustical sealant for exposed joints:
 - 1. Type: Manufacturer's standard nonsag, paintable, nonstaining latex acoustical sealant complying with ASTM C834.
 - 2. Acceptable products:
 - a. Accumetric LLC; BOSS 826 Acoustical Sound Sealant.
 - b. GE Construction Sealants; RCS20 Acoustical.
 - c. Grabber Construction Products; Acoustical Sealant GSC.
 - d. Pecora Corporation; AC-20 FTR or AIS-919.
 - e. Tremco, Incorporated; Tremco Acoustical Sealant.
 - f. United State Gypsum Company; SHEETROCK Acoustical Sealant.
 - 3. Colors: Standard colors as selected by Architect.
- C. Acoustical sealant for concealed joints:
 - 1. Type: Manufacturer's standard nonsag, nondrying, nonhardening, nonskinning, nonstaining, gunnable, synthetic-rubber acoustical sealant.
 - 2. Acceptable products:
 - a. Pecora Corporation; BA-98.
 - b. Serious Energy Inc.; Quiet Seal 350.
- D. Acoustical sealant tape for concealed joints:
 - 1. Type: Preformed, precompressed, open-cell foam sealant in roll form, coated on one side with a pressure-sensitive adhesive and covered with protective wrapping.
 - 2. Acceptable manufacturers:
 - a. Basis of design; Emseal Corp., Emseal Quiet Joint.
 - b. C. R. Laurence Co., Inc.
 - c. Sandell Manufacturing Co., Inc.
 - d. Schul International Company, Inc.
 - 3. Thickness: As required by manufacturer's product data for actual joint width.
- E. Miscellaneous materials:
 - 1. Primer: Material recommended by acoustical-joint-sealant manufacturer where required for adhesion of sealant to joint substrates.
 - 2. Cleaners for nonporous surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials, free of oily residues or other substances capable of staining or harming joint substrates and adjacent nonporous surfaces in any way, and formulated to promote optimum adhesion of sealants to joint substrates.

3. Masking tape: Nonstaining, nonabsorbent material compatible with joint sealants and surfaces adjacent to joints.

2.10 PRECOMPRESSED FOAM SEALANT:

- A. Acceptable product:
 1. Emseal Corp., Emseal Backerseal.
 2. Sandell Manufacturing Co., Inc., Polyseal.
 3. Schul International Company, Inc., Sealtite B.
- B. Characteristics:
 1. Type: Manufacturer's standard preformed, precompressed, open-cell foam sealant manufactured from urethane foam with minimum density of 10 lb/cu. ft. and impregnated with a nondrying, water-repellent agent. Factory produce in precompressed roll or stick form; coated on one side with a pressure-sensitive adhesive and covered with protective wrapping.
 2. Thickness: As required by manufacturer's product data for actual joint width.

2.11 ACCESSORY MATERIALS:

- A. Joint cleaner: Type recommended by material manufacturer for substrates indicated.
- B. Joint primer/sealer: Type recommended by material manufacturer for substrates, conditions and exposures indicated.
- C. Bond breaker tape: Plastic tape applied to contact surfaces where bond to substrate or joint filler must be avoided for material performance.
- D. Sealant backer rod: Compressible rod stock as recommended by sealant manufacturer for compatibility with sealant. Provide size and shape of rod to control joint depth.
- E. Tooling agent: Agent recommended by material manufacturer to ensure contact of material with inner joint faces.
- F. Weep tubes and foam baffles for rain screen joints: Provide 1/4" inside diameter, clear plastic tubing and non-deteriorating foam baffles for rain screen caulk joints.

PART 3 - EXECUTION

3.1 JOB MOCK-UP:

- A. Prepare, caulk and finish one mock-up sample of each joint condition.
- B. Sample joints shall be approved by Architect prior to beginning work. Approved, undamaged mock-up joints shall serve as a standard of quality for the remainder of the work.
- C. Install sealant in mockups of assemblies specified in other Sections that are indicated to receive joint sealants specified in this Section. Use materials and installation methods specified in this Section.

3.2 RE-CAULKING EXISTING PRECAST CONCRETE PANELS:

- A. Re-caulk/re-seal procedures:
 1. The original seals and backer rods are to be completely removed from the joint;
 2. Joint interfaces be ground to produce a clean and even surface (10mm joint width);
 3. Dust must be removed from interface;
 4. Backing rod (over-sized 30-50%) be compressed in-between substrates;
 5. Backer must be positioned (using a rolling tool) within the joint, maintaining a 5-mm joint thickness;

6. Panel surfaces must then be masked prior to applying sealant to joint;
7. Sealant compound is to be tooled after the sealant is applied to the joint;
8. Masking tape and excess sealant removed.
9. Application to be undertaken during dry conditions.
10. All joints and routed cracks will be prepared to produce a sound, dry, and clean surface for adhesion. All existing sealant from the panel and window perimeter joints will be removed; the concrete surface will then be ground free of all sealant.
11. All sealant tape and dirt will be removed from glazing. All contact surfaces will be cleaned with a recommended solvent using a clean lint free cloth.
12. Backing rod will be installed into the joint allowing for a 1:2 depth to width ratio. Areas surrounding the joint will be masked.

B. Installation:

1. Installation will only proceed if the environmental conditions are within the sealant manufacturer's specified tolerance. All multi-component sealants will be mixed thoroughly. Nozzles will be cut to suit joint width.
2. Sealant will be gunned into the joint and 'tooled off' to provide good adhesion onto the substrates.

C. Re-seal/Re-caulk inspection:

1. An independent consultant will undertake inspection of the re-sealed joints at regular intervals throughout the maintenance program.
2. The sealant supplier will undertake a minimum of one inspection. The supplier will provide written reports on preparation and installation methods immediately after the inspection. The consultant will be supplied with samples of proposed sealants; each sample will be clearly labeled showing material and application details.
3. An independent inspector will review of the resealed joint. A hand-pull test was used (2 weeks after application) to evaluate the performance and geometry of the joint.
 - a. The test involves pulling a 50-mm strip of sealant at a 90 degree angle to the panel and the sample should elongate at least 100% before cohesive or adhesion failure. If the sample fails prematurely then the joint must be resealed.
 - b. Once the test is complete, the sealant geometry can be measured for the correct depth to width ratio; if the geometry is incorrect then the joint must be resealed. Pull-tests of joint samples were taken at every floor level on all elevations; samples were taken at horizontal distances of 4m. Failure to meet the minimum performance criteria for pull tests or sealant geometry resulted in additional cuts being performed to establish the extent of any potential deficiencies.
4. Prior to the start of the maintenance program, the consultant will review methods of sealant removal. A sample window and cast-in-place panel will be prepared (i.e. facade mock-up) prior to the contractor undertaking the building re-sealing

D. Two-Stage Sealant Design at Parapet Conditions:

1. Install open cell rod behind the interior sealant.
2. Install closed cell rod behind the exterior sealant.

3.3 NEW CONSTRUCTION JOINT SURFACE PREPARATION:

- A. Clean joints of debris and projections including shims.
- B. Clean joint surfaces immediately before caulking joints. Remove dirt, insecure coatings, moisture and other substances which would interfere with bond.
- C. Etch concrete and masonry joint surfaces to remove excess alkalinity, unless material manufacturer's product data indicates that alkalinity does not interfere with bond and performance. Etch with 5% solution of muriatic acid; neutralize with dilute ammonia solution; rinse with clean water and allow to dry before caulking.

- D. Roughen joint surfaces of non-porous materials, unless material manufacturer's product data indicates equal bond strength as porous surfaces. Rub with fine abrasive cloth or wool to produce dull sheen.

3.4 APPLICATION:

- A. Comply with caulking material manufacturer's product data and ASTM C1193-09 except where more stringent requirements are specified.
- B. Prime joint surfaces where recommended by material manufacturer. Do not allow primer/sealer to spill or migrate onto adjacent surfaces.
- C. Install backer rod for caulking materials, except where recommended by material manufacturer to be omitted for application indicated.
 - 1. Place backer rod to maintain recommended sealant thickness and profile.
 - 2. Place rod at depth to provide sealant manufacturer's recommended sealant depth.
 - 3. Do not twist rod during installation.
 - 4. Place rod to minimize possibility of extrusion when joint is compressed.
 - 5. Install bond breaker tape in lieu of backer rod for shallow, closed joints and as recommended by manufacturer's product data.
- D. Employ installation techniques which will ensure that materials are deposited in uniform, continuous ribbons without gaps or air pockets, with complete wetting of joint bond surfaces. Where horizontal joints are between a horizontal surface and a vertical surface, fill joint to form slight cove so that joint will not trap moisture and debris.
- E. Do not allow materials to overflow onto adjacent surfaces. Prevent staining of adjacent surfaces.
- F. Remove excess and misplaced materials as work progresses. Clean the adjoining surfaces to remove misplaced materials, without damage to adjacent surfaces or finishes.
- G. Interior joints: At interior joints and seams at abutting and adjacent materials, recess caulking compound 3/16" in joints wider than 1/4". At joints 1/4" or less in width, tool caulking flush.
- H. Tool joints of non-sag sealant to concave profile and smooth, uniform surface, flush with edges of substrate. Maintain sealant depth-to-width ratio in accord with manufacturer's product data.
- I. Cure sealants and caulking compounds in accord with manufacturer's product data to obtain high early bond strength, internal cohesive strength and surface durability. Protect uncured surfaces from contamination and physical damage.
- J. Install weep tubes in rain screen joint configuration as detailed and at locations indicated. Position tubes to allow slope for drainage extending 1/8" beyond face of exterior surface. Install foam baffles as indicated.

3.5 CLEANING:

- A. Clean off excess sealant or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

3.6 PROTECTION:

- A. Protect joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out, remove, and repair damaged or deteriorated joint sealants immediately so installations with repaired areas are indistinguishable from original work.

3.7 CAULKING SCHEDULE:

- A. Joint-Sealant Application: Exterior joints in vertical surfaces and horizontal nontraffic surfaces:
1. Joint Locations:
 - a. Weather seals at joints between window walls and metal frames.
 - b. Perimeter joints between materials listed above and frames of windows.
 - c. Control and expansion joints in overhead surfaces.
 - d. Other joints as indicated on Drawings.
 2. Joint Sealant: Medium modulus silicone.
 3. Joint-Sealant Color: Match Architect's sample.
- B. Joint-Sealant Application: Exterior joints in vertical surfaces and horizontal nontraffic surfaces.
1. Joint Locations:
 - a. Construction joints in cast-in-place concrete.
 - b. Control and expansion joints in masonry.
 - c. Joints between different materials listed above.
 - d. Perimeter joints between materials listed above and frames of windows.
 - e. Control and expansion joints in overhead surfaces.
 - f. Cement plaster.
 - g. Other joints in porous substrates as indicated on Drawings.
 2. Joint Sealant: Low modulus silicone.
 3. Joint-Sealant Color: Match Architect's sample.
- C. Joint-Sealant Application: Mildew-resistant interior joints in vertical surfaces and horizontal nontraffic surfaces
1. Joint Sealant Location:
 - a. Joints between plumbing fixtures and adjoining walls, floors, and millwork counters, between backsplash and walls.
 - b. Joints between toilet accessories and adjoining walls, floors and counters.
 - c. Control and expansion joints in or around surfaces of ceramic tile, solid surfacing materials, and plastic laminate in toilet rooms, and other wet areas subject to moisture and mildew.
 - d. Other joints as indicated.
 2. Joint Sealant: Mildew resistant, single component, nonsag, neutral or acid curing, Silicone.
 3. Joint-Sealant Color: Match Architect's sample.
- D. Joint-Sealant Application: Interior joints in horizontal traffic surfaces.
1. Joint Locations:
 - a. Construction joints in cast-in-place concrete.
 - b. Control and expansion joints in tile flooring.
 - c. Joints between different materials listed above.
 - d. Other joints as indicated.
 2. Elastomeric, Urethane Joint Sealant.
 3. Joint-Sealant Color: Match Architect's samples for each area indicated.
- E. Joint-Sealant Application: Interior joints in vertical surfaces and horizontal nontraffic surfaces.
1. Joint Locations:
 - a. Perimeter joints between interior wall surfaces and frames of interior doors, windows, and elevator entrances.
 - b. Field-painted vertical and overhead gypsum board surfaces.
 - c. Other interior locations not indicated otherwise.
 - d. Other joints as indicated.
 2. Joint Sealant: Acrylic based.
 3. Joint-Sealant Color: As selected by Architect from manufacturer's full range of colors.

- F. Joint-Sealant Application: Interior joints in vertical surfaces and horizontal nontraffic surfaces.
 - 1. Joint Locations:
 - a. Control and expansion joints on exposed interior surfaces of exterior walls.
 - b. Perimeter joints of exterior openings where indicated.
 - c. Tile control and expansion joints.
 - d. Vertical joints on exposed surfaces of interior unit masonry concrete walls and partitions.
 - e. Other joints as indicated.
 - 2. Urethane Joint Sealant: Single component, nonsag, Class 25.
 - 3. Joint-Sealant Color: As selected by Architect from manufacturer's full range of colors.
- G. Joint-Sealant Application: Concealed mastics.
 - 1. Joint Locations:
 - a. Aluminum thresholds.
 - b. Sill plates.
 - c. Other joints as indicated on Drawings.
 - 2. Joint Sealant: Butyl-rubber based.
 - 3. Joint-Sealant Color: As selected by Architect from manufacturer's full range of colors.
- H. Exterior joints between wall finish and conduit and pipe penetrations, base plates of light fixtures, signage supports, and other items applied to exterior wall surface: Medium modulus silicone sealant.

END OF SECTION

SECTION 08 1113 - HOLLOW METAL FRAMES

PART 1 - GENERAL

1.1 SUMMARY:

- A. Related work specified elsewhere:
 - 1. Masonry.
 - 2. Glazing.
 - 3. Gypsum board.
 - 4. Painting and Coating.

1.2 PERFORMANCE REQUIREMENTS:

- A. Physical endurance: Comply with performance level for specified level classification in accord with ANSI A250.8-2003(R2008) and ANSI A250.4-01 for hardware reinforcing, ANSI A250.4-01 for frames, frame anchors and hardware reinforcing.
- B. Finish: Comply with standard performance criteria of ANSI A250.10 for primed steel surfaces.
- C. Fire-rated assemblies: Complying with NFPA 80 and listed and labeled by a qualified testing agency acceptable to authorities having jurisdiction for fire-protection ratings indicated, and temperature-rise limits where required, based on testing at positive pressure according to NFPA 252 or UL 10C.
 - 1. Smoke- and draft-control assemblies: Provide an assembly with gaskets listed and labeled for smoke and draft control by a qualified testing agency acceptable to authorities having jurisdiction, based on testing according to UL 1784 and installed in compliance with NFPA 105.
 - 2. Fire-rated, borrowed-light assemblies: Complying with NFPA 80 and listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction for fire-protection ratings indicated, based on testing according to NFPA 257 or UL 9.
- D. Thermal performance: Minimum aged value of $U = 0.10$ ($R = 10.2$) or better, apparent thermal performance in accord with SDI-113.
- E. Acoustical performance: STC of 25 or better in accord with SDI-128, ASTM E90 and ASTM E413.

1.3 ACTION SUBMITTALS:

- A. Product data: Indicate that hollow metal frames comply with specified requirements, including performance criteria.
- B. Shop drawings: Indicate frame elevations and sections, materials, gauges and finishes, fabrication and erection details, location of finish hardware by dimension and locations, and fire rating requirements.
- C. Samples: Submit as follows:
 - 1. Welded frame: 1'-0" by 1'-0" head and jamb corner section showing welded corner construction.
 - 2. Anchors: One of each type.

1.4 INFORMATIONAL SUBMITTALS:

- A. Product Test Reports: For each type of hollow-metal frame assembly, for tests performed by a qualified testing agency.

1.5 QUALITY ASSURANCE:

- A. Applicable standards; standards of the following, as referenced herein:
 - 1. American National Standards Institute, Inc. (ANSI).
 - 2. ASTM International (ASTM).
 - 3. National Fire Protection Association (NFPA), National Fire Codes.
 - 4. Society for Protective Coatings (SSPC).
 - 5. Steel Door Institute (SDI).
 - 6. Underwriters Laboratories, Inc. (UL).
- B. Fabrication standard: Except for more stringent requirements specified, comply with ANSI A250.8-2003(R2008) including performance levels as referenced.

1.6 DELIVERY, STORAGE AND HANDLING:

- A. Mark each hollow metal frame at top hinge and on outside of packaging with destination door mark indicated on door schedule.
- B. Deliver hollow metal frames palletized, packaged or crated for protection during transit and site storage.
 - 1. Do not use nonvented plastic.
 - 2. Deliver welded frames with two removable spreader bars across bottom of frames, tack welded to jambs and mullions.
 - 3. Provide additional protection to prevent damage to factory-finished units.
- C. Inspect work upon delivery for damage. Reject damaged items.
- D. Store materials under cover, on raised platforms.
 - 1. Stack a maximum of five assembled frame units vertically with minimum 1/4" spacers between units.
 - 2. Protect from moisture but provide for cross ventilation. Remove units from wet containers if wetting occurs.

PART 2 - PRODUCTS

2.1 APPROVED MANUFACTURERS:

- A. Acceptable manufacturers:
 - 1. Ceco Door; ASSA ABLOY.
 - 2. Curries Company; ASSA ABLOY.
 - 3. Deansteel Manufacturing Company, Inc.
 - 4. Republic Doors and Frames.

2.2 MATERIAL:

- A. Steel:
 - 1. Interior frames: Fabricate of cold-rolled steel sheet meeting ASTM A1008.
 - 2. Exterior frames: Fabricate of commercial quality, hot dip galvanized or galvanized steel sheet meeting ASTM A653 Designation A60 or G60; wipe coat not acceptable.
- B. Finish: Prime painted steel surfaces shall comply with requirements for acceptance stated in ANSI A250.3.
 - 1. Interior frames: One coat of manufacturer's standard rust-inhibitive primer.
 - 2. Exterior frames: One coat of manufacturer's standard rust-inhibitive primer after chemical treatment of galvanized surfaces for paint adhesion.
- C. Coating for inside of frames to be fully grouted in masonry and concrete construction: Field applied bituminous coating:
 - 1. Cold-applied asphalt emulsion complying with ASTM D1187/D1187M; compounded for 15-mil dry film thickness per coat.
 - 2. Provide inert-type non-corrosive compound free of asbestos fibers, sulfur components, and other deleterious impurities.

2.3 FRAMES:

A. Frame construction:

1. Welded steel frames in all exterior construction: 14 ga., with backbend returns.
 - a. Setup arc welded, with all joints, including face, flange and throat, full welded, dressed and ground smooth; no mechanical interlocking allowed.
 - b. Provide welded frames with temporary spreaders during shipping, storage and erection. Spreader shall span both rabbets of frame and be located at bottom and at middle of frame.
2. Transom bars and mullions: Shop fabricate from same material as door frames.
 - a. Setup arc welded, with all joints, including face, flange and throat, full welded, dressed and ground smooth; no mechanical interlocking allowed.
 - b. Fabricate in largest size sections allowed by shipping and installation restrictions. Field joints shall occur only as indicated on approved shop drawings.
3. Machine door frames for hardware scheduled for installation on that frame. Filler plates installed at unused openings will not be acceptable. Provide blockouts behind frame for continuous hinges.
4. Joints:
 - a. Dress welded joints and ground smooth, indistinguishable in completed work.
 - b. Make non-welded connections with tight fitting, closed joints.
 - c. Make joints with aligned faces and arrises.
5. Inside of frames to be grouted in masonry and concrete construction shall receive protective coating as specified herein.
6. Loose glazing stops:
 - a. Removable glazing stops shall be cold rolled steel, no less than 20 gage, butted at corner joints and secured to frame using cadmium or zinc plated #6 countersunk sheet metal screws at 1'-0" o.c. maximum.
 - b. Frame underneath glazing stops and inside of glazing stop shall be treated for maximum paint adhesion and shall receive factory spray-applied high-build epoxy coating specified herein, 4 to 6 mils dft., prior to installation in frame.

B. Frame anchors:

1. Wall anchors for frame attachment to masonry construction: Adjustable, flat, minimum 18 gage corrugated or perforated, T-shaped steel anchors with leg not less than 2" wide by 10" long. Provide one anchor per jamb for each 2'-0" of height or fraction thereof. Anchors for fire-rated frames shall be labeled type.
2. Wall anchors for frame attachment to drywall partitions: Manufacturer's standard adjustable type for attachment to studs. Provide one anchor per jamb for each 2'-0" of height or fraction thereof. Anchors for fire-rated frames shall be labeled type.
3. Floor anchors: Provide frames, other than slip-on drywall type, with minimum 18 gage anchors for attachment to floor.
 - a. For wall conditions that do not allow for the use of a floor anchor, provide an additional jamb anchor.
 - b. Anchors for fire-rated frames shall be labeled type.
4. Head struts: For frames over 7'-0" high and not anchored to masonry or concrete construction, provide 1/4" by 2" steel struts spot welded to jambs, each side, extending to building structure. Attach to structure. For frames over 4'-0" in width, provide center strut at head.
5. In-place concrete: 3/8" countersunk, flat head, stove bolts in expansion shields, spaced 6" maximum from top and bottom of frame and at 2'-0" o. c., maximum, between. Anchors for fire-rated frames shall be labeled type.

2.4 ACCESSORIES:

- A. Astragals: As required by NFPA 80 to provide fire ratings indicated.

2.5 PREPARATION FOR HARDWARE AND ANCHORS:

- A. Reinforcement: Factory reinforce frame components for hardware installation in accord with ANSI A250.8-2003(R2008) and ANSI A250.6-2003.

- B. Punch single leaf frames to receive three silencers; double leaf frames to receive two silencers per leaf, at head.
- C. Provide grout shields where frames in masonry walls are cut or drilled.
- D. Install hardware reinforcement and anchors without distortions or blemishes on exposed surfaces.

PART 3 - EXECUTION

3.1 FRAME INSTALLATION:

- A. General:
 - 1. Install hollow metal frames in accord with ANSI/SDI A250.8-2003(R2008), ANSI A250.11-2001, SDI-122-07, manufacturer's product data and approved shop drawings.
 - 2. Frames in masonry walls and fire-rated frames shall be tightly butted to walls. For other frames, clearance between frame and interfacing wall surfaces shall be 1/16" maximum.
 - 3. Shimming of door hinges is not an acceptable correction of door frames installed out of erection tolerance.
- B. Welded frames:
 - 1. Set welded frames in position prior to beginning partition work. Brace frames until permanent anchors are set.
 - 2. Set anchors for frames as work progresses. Install anchors at hinge and strike levels. Install rubber bumpers and silencers in frames prior to grouting.
 - 3. Grout frames in masonry walls.
 - 4. Remove temporary spreaders before frame installation is complete.
 - 5. Remove temporary braces after wall construction is complete.
 - 6. Install welded frames in prepared openings in concrete and masonry walls using countersunk bolts and expansion shields.
- C. Fire-rated frames: Install in accord with requirements of NFPA No. 80 and ANSI A250.11-2001.

3.2 SITE TOLERANCES:

- A. Allowable erection tolerances:
 - 1. Variation from specified clearances: +1/32".
 - 2. Variation in face alignment, pairs of doors: +1/16".
 - 3. Variation in face alignment between door and frame: 1/8" maximum.

3.3 CLEANING AND PROTECTION:

- A. Protect hollow metal frames from damage and staining until Date of Substantial Completion. Replace or repair damaged or stained components.
- B. Replace components which exhibit warp, buckle or broken welds.

END OF SECTION

SECTION 081113 - HOLLOW METAL DOORS AND FRAMES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes:

1. Interior standard steel doors and frames.
2. Exterior standard steel doors and frames.
3. Interior custom hollow-metal doors and frames.
4. Exterior custom hollow-metal doors and frames.

- B. Related Requirements:

1. Section 081119 "Stainless-Steel Doors and Frames" for hollow-metal doors and frames manufactured from stainless steel.
2. Section 083463 "Detention Doors and Frames" for hollow-metal doors and frames for detention facilities.
3. Section 083473.13 "Metal Sound Control Door Assemblies" for packaged, acoustically rated hollow-metal door and frame assemblies.
4. **Section 087100 Builder's Hardware** for door hardware for hollow-metal doors.
5. Section 134900 "Radiation Protection" for lead-lined, hollow-metal doors and frames.

1.3 DEFINITIONS

- A. Minimum Thickness: Minimum thickness of base metal without coatings according to NAAMM-HMMA 803 or ANSI/SDI A250.8.

1.4 COORDINATION

- A. Coordinate anchorage installation for hollow-metal frames. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors. Deliver such items to Project site in time for installation.
- B. Coordinate requirements for installation of door hardware, electrified door hardware, and access control and security systems.

1.5 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at **Project site**.

1.6 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, core descriptions, **fire-resistance ratings**, and finishes.
- B. Sustainable Design Submittals:
 - 1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.
- C. Shop Drawings: Include the following:
 - 1. Elevations of each door type.
 - 2. Details of doors, including vertical- and horizontal-edge details and metal thicknesses.
 - 3. Frame details for each frame type, including dimensioned profiles and metal thicknesses.
 - 4. Locations of reinforcement and preparations for hardware.
 - 5. Details of each different wall opening condition.
 - 6. Details of electrical raceway and preparation for electrified hardware, access control systems, and security systems.
 - 7. Details of anchorages, joints, field splices, and connections.
 - 8. Details of accessories.
 - 9. Details of moldings, removable stops, and glazing.
- D. Samples for Initial Selection: For hollow-metal doors and frames with factory-applied color finishes.
- E. Samples for Verification:
 - 1. Finishes: For each type of exposed finish required, prepared on Samples of not less than 3 by 5 inches (75 by 127 mm).
 - 2. Fabrication: Prepare Samples approximately **8 by 10 inches (203 by 254 mm)** to demonstrate compliance with requirements for quality of materials and construction:
 - a. Doors: Show vertical-edge, top, and bottom construction; core construction; and hinge and other applied hardware reinforcement. Include separate section showing glazing if applicable.
 - b. Frames: Show profile, corner joint, floor and wall anchors, and silencers. Include separate section showing fixed hollow-metal panels and glazing if applicable.

- F. Product Schedule: For hollow-metal doors and frames, prepared by or under the supervision of supplier, using same reference numbers for details and openings as those on Drawings. Coordinate with final door hardware schedule.

1.7 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For door inspector.
 - 1. Fire-Rated Door Inspector: Submit documentation of compliance with NFPA 80, Section 5.2.3.1.
 - 2. Egress Door Inspector: Submit documentation of compliance with NFPA 101, Section 7.2.1.15.4.
 - 3. Submit copy of DHI Fire and Egress Door Assembly Inspector (FDAI) certificate.
- B. Product Test Reports: For each type of **[fire-rated hollow-metal door and frame assembly] [fire-rated borrowed-lite assembly]** for tests performed by a qualified testing agency indicating compliance with performance requirements.
- C. Oversize Construction Certification: For assemblies required to be fire-rated and exceeding limitations of labeled assemblies.
- D. Field quality control reports.

1.8 CLOSEOUT SUBMITTALS

- A. Record Documents: For fire-rated doors, list of door numbers and applicable room name and number to which door accesses.

1.9 QUALITY ASSURANCE

- A. Fire-Rated Door Inspector Qualifications: Inspector for field quality control inspections of fire-rated door assemblies shall meet the qualifications set forth in NFPA 80, section 5.2.3.1 and the following:
 - 1. Door and Hardware Institute Fire and Egress Door Assembly Inspector (FDAI) certification.
- B. Egress Door Inspector Qualifications: Inspector for field quality control inspections of egress door assemblies shall meet the qualifications set forth in NFPA 101, Section 7.2.1.15.4 and the following:
 - 1. Door and Hardware Institute Fire and Egress Door Assembly Inspector (FDAI) certification.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Deliver hollow-metal doors and frames palletized, packaged, or crated to provide protection during transit and Project-site storage. Do not use nonvented plastic.
 - 1. Provide additional protection to prevent damage to factory-finished units.
- B. Deliver welded frames with two removable spreader bars across bottom of frames, tack welded to jambs and mullions.
- C. Store hollow-metal doors and frames vertically under cover at Project site with head up. Place on minimum 4-inch- (102-mm-) high wood blocking. Provide minimum 1/4-inch (6-mm) space between each stacked door to permit air circulation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2.2 PERFORMANCE REQUIREMENTS

- A. Fire-Rated Door Assemblies: Assemblies complying with NFPA 80 that are listed and labeled by a qualified testing agency acceptable to authorities having jurisdiction for fire-protection ratings[**and temperature-rise limits**] indicated on Drawings, based on testing at positive pressure according to NFPA 252 or UL 10C.
 - 1. Smoke- and Draft-Control Door Assemblies: Listed and labeled for smoke and draft control by a qualified testing agency acceptable to authorities having jurisdiction, based on testing according to UL 1784 and installed in compliance with NFPA 105.
 - 2. Oversize Fire-Rated Door Assemblies: For units exceeding sizes of tested assemblies, provide certification by a qualified testing agency that doors comply with standard construction requirements for tested and labeled fire-rated door assemblies except for size.
- B. Fire-Rated, Borrowed-Lite Assemblies: Assemblies complying with NFPA 80 and listed and labeled by a qualified testing agency acceptable to authorities having jurisdiction, for fire-protection ratings indicated, based on testing according to NFPA 257 or UL 9.
- C. Windborne-Debris Impact Resistance: Passes ASTM E1886 missile-impact and cyclic-pressure tests in accordance with ASTM E1996 for Wind Zone [1] [2] [3] [4] for [**basic**] [**enhanced**] protection.
 - 1. Large-Missile Test: For glazed openings located within [**30 feet (9.1 m)**] **<Insert dimension>** of grade.

- D. Thermally Rated Door Assemblies: Provide door assemblies with U-factor of not more than **[0.50 deg Btu/F x h x sq. ft. (2.84 W/K x sq. m)] [0.40 deg Btu/F x h x sq. ft. (2.27 W/K x sq. m)] [0.38 deg Btu/F x h x sq. ft. (2.16 W/K x sq. m)]** when tested according to ASTM C518.

2.3 INTERIOR STANDARD STEEL DOORS AND FRAMES

- A. Construct hollow-metal doors and frames to comply with standards indicated for materials, fabrication, hardware locations, hardware reinforcement, tolerances, and clearances, and as specified.
- B. Standard-Duty Doors and Frames: ANSI/SDI A250.8, Level 1; ANSI/SDI A250.4, Level C. **At locations indicated in the Door and Frame Schedule.**

1. Doors:

- a. Type: As indicated in the Door and Frame Schedule.
- b. Thickness: **1-3/4 inches (44.5 mm).**
- c. Face: **[Uncoated] [Metallic-coated]** steel sheet, minimum thickness of 0.032 inch (0.8 mm).
- d. Edge Construction: **Model 1, Full Flush.**
- e. Edge Bevel: **Bevel lock and hinge edges 1/8 inch in 2 inches (3.2 mm in 51 mm) Bevel lock edge 1/8 inch in 2 inches (3.2 mm in 51 mm) Provide manufacturer's standard beveled or square edges.**
- f. Core: **Manufacturer's standard.**
- g. Fire-Rated Core: Manufacturer's standard **vertical steel stiffener** core for fire-rated doors.

2. Frames:

- a. Materials: **Uncoated** steel sheet, minimum thickness of 0.042 inch (1.0 mm).
- b. **Sidelite and Transom** Frames: Fabricated from same thickness material as adjacent door frame.
- c. Construction: **Face welded.**

3. Exposed Finish: **[Prime] [Factory].**

4. Exposed Finish: **[Prime] [Factory].**

2.4 EXTERIOR STANDARD STEEL DOORS AND FRAMES

- A. Construct hollow-metal doors and frames to comply with standards indicated for materials, fabrication, hardware locations, hardware reinforcement, tolerances, and clearances, and as specified.
- B. Heavy-Duty Doors and Frames: ANSI/SDI A250.8, Level 2; ANSI/SDI A250.4, Level B. **At locations indicated in the Door and Frame Schedule.**

1. Doors:
 - a. Type: As indicated in the Door and Frame Schedule.
 - b. Thickness: 1-3/4 inches (44.5 mm).
 - c. Face: Metallic-coated steel sheet, minimum thickness of 0.042 inch (1.0 mm), with minimum **[A40 (ZF120)] [A60 (ZF180)]** coating.
 - d. Edge Construction: **[Model 1, Full Flush] [Model 2, Seamless]**.
 - e. Edge Bevel: **[Bevel lock and hinge edges 1/8 inch in 2 inches (3.2 mm in 51 mm)] [Bevel lock edge 1/8 inch in 2 inches (3.2 mm in 51 mm)] [Provide manufacturer's standard beveled or square edges]**.
 - f. Top Edge Closures: Close top edges of doors with flush closures of same material as face sheets. Seal joints against water penetration.
 - g. Bottom Edges: Close bottom edges of doors **[where required for attachment of weather stripping]** with end closures or channels of same material as face sheets. Provide weep-hole openings in bottoms of exterior doors to permit moisture to escape.
 - h. Core: **[Manufacturer's standard] [Polystyrene] [Polyurethane] [Polyisocyanurate] [Vertical steel stiffener]**.
 - i. Fire-Rated Core: Manufacturer's standard **[vertical steel stiffener with insulation] [laminated mineral board]** core for fire-rated doors.
2. Frames:
 - a. Materials: Metallic-coated steel sheet, minimum thickness of 0.053 inch (1.3 mm), with minimum **[A40 (ZF120)] [A60 (ZF180)]** coating.
 - b. Construction: **[Knocked down] [Face welded] [Full profile welded]**.
3. Exposed Finish: **[Prime] [Factory]**.

2.5 FRAME ANCHORS

- A. Jamb Anchors:
 1. Type: Anchors of minimum size and type required by applicable door and frame standard, and suitable for performance level indicated.
 2. Quantity: Minimum of three anchors per jamb, with one additional anchor for frames with no floor anchor. Provide one additional anchor for each 24 inches (610 mm) of frame height above 7 feet (2.1 m).
 3. Postinstalled Expansion Anchor: Minimum 3/8-inch- (9.5-mm-) diameter bolts with expansion shields or inserts, with manufacturer's standard pipe spacer.
- B. Floor Anchors: Provide floor anchors for each jamb and mullion that extends to floor.
- C. Floor Anchors for Concrete Slabs with Underlayment: Adjustable-type anchors with extension clips, allowing not less than 2-inch (51-mm) height adjustment. Terminate bottom of frames at top of underlayment.
- D. Material: ASTM A879/A879M, Commercial Steel (CS), 04Z (12G) coating designation; mill phosphatized.

1. For anchors built into exterior walls, steel sheet complying with ASTM A1008/A1008M or ASTM A1011/A1011M; hot-dip galvanized according to ASTM A153/A153M, Class B.

2.6 MATERIALS

- A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than **25** percent.
- B. Cold-Rolled Steel Sheet: ASTM A1008/A1008M, Commercial Steel (CS), Type B; suitable for exposed applications.
- C. Hot-Rolled Steel Sheet: ASTM A1011/A1011M, Commercial Steel (CS), Type B; free of scale, pitting, or surface defects; pickled and oiled.
- D. Metallic-Coated Steel Sheet: ASTM A653/A653M, Commercial Steel (CS), Type B.
- E. Inserts, Bolts, and Fasteners: Hot-dip galvanized according to ASTM A153/A153M.
- F. Power-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hollow-metal frames of type indicated.
- G. Mineral-Fiber Insulation: ASTM C665, Type I (blankets without membrane facing); consisting of fibers manufactured from slag or rock wool; with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively; passing ASTM E136 for combustion characteristics.
- H. Glazing: Comply with requirements in Section 088000 "Glazing."

2.7 FABRICATION

- A. Door Astragals: Provide overlapping astragal on one leaf of pairs of doors where required by NFPA 80 for fire-performance rating or where indicated. Extend minimum 3/4 inch (19 mm) beyond edge of door on which astragal is mounted or as required to comply with published listing of qualified testing agency.
- B. Hollow-Metal Frames: Fabricate in one piece except where handling and shipping limitations require multiple sections. Where frames are fabricated in sections, provide alignment plates or angles at each joint, fabricated of metal of same or greater thickness as frames.
 1. **[Sidelite] [and] [Transom Bar]** Frames: Provide closed tubular members with no visible face seams or joints, fabricated from same material as door frame. Fasten members at crossings and to jambs by welding[, **or by rigid mechanical anchors**].
 2. Provide countersunk, flat- or oval-head exposed screws and bolts for exposed fasteners unless otherwise indicated.

3. Door Silencers: Except on weather-stripped frames, drill stops to receive door silencers as follows. Keep holes clear during construction.
 - a. Single-Door Frames: Drill stop in strike jamb to receive three door silencers.
 - b. Double-Door Frames: Drill stop in head jamb to receive two door silencers.
 4. Terminated Stops (Hospital Stops): Terminate stops **[6 inches (152 mm)]** **<Insert dimension>** above finish floor with a **[45] [90]**-degree angle cut, and close open end of stop with steel sheet closure. Cover opening in extension of frame with welded-steel filler plate, with welds ground smooth and flush with frame.
- C. Hardware Preparation: Factory prepare hollow-metal doors and frames to receive templated mortised hardware, and electrical wiring; include cutouts, reinforcement, mortising, drilling, and tapping according to ANSI/SDI A250.6, the Door Hardware Schedule, and templates.
1. Reinforce doors and frames to receive nontemplated, mortised, and surface-mounted door hardware.
 2. Comply with BHMA A156.115 for preparing hollow-metal doors and frames for hardware.
- D. Glazed Lites: Provide stops and moldings around glazed lites where indicated. Form corners of stops and moldings with **mitered** hairline joints.
1. Provide stops and moldings flush with face of door, and with **square** stops unless otherwise indicated.
 2. Multiple Glazed Lites: Provide fixed and removable stops and moldings so that each glazed lite is capable of being removed independently.
 3. Provide fixed frame moldings on outside of exterior and on secure side of interior doors and frames. Provide loose stops and moldings on inside of hollow-metal doors and frames.
 4. Coordinate rabbet width between fixed and removable stops with glazing and installation types indicated.
 5. Provide stops for installation with countersunk flat- or oval-head machine screws spaced uniformly not more than 9 inches (230 mm) o.c. and not more than 2 inches (51 mm) o.c. from each corner.

2.8 STEEL FINISHES

- A. Prime Finish: Clean, pretreat, and apply manufacturer's standard primer.
1. Shop Primer: Manufacturer's standard, fast-curing, lead- and chromate-free primer complying with ANSI/SDI A250.10; recommended by primer manufacturer for substrate; compatible with substrate and field-applied coatings despite prolonged exposure.

- B. Factory Finish: Clean, pretreat, and apply manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat, complying with ANSI/SDI A250.3.

- 1. Color and Gloss: **As selected by Architect from manufacturer's full range.**

2.9 LOUVERS

- A. Provide louvers for interior doors, where indicated, which comply with SDI 111, with blades or baffles formed of 0.020-inch- (0.5-mm-) thick, cold-rolled steel sheet set into 0.032-inch- (0.8-mm-) thick steel frame.
 - 1. Sightproof Louver: Stationary louvers constructed with inverted-V or inverted-Y blades.
 - 2. Lightproof Louver: Stationary louvers constructed with baffles to prevent light from passing from one side to the other.
 - 3. Fire-Rated Automatic Louvers: Louvers constructed with movable blades closed by actuating fusible link, and listed and labeled for use in fire-rated door assemblies of type and fire-resistance rating indicated by same qualified testing and inspecting agency that established fire-resistance rating of door assembly.
- B. Form corners of moldings with hairline joints. Provide fixed frame moldings on outside of exterior and on secure side of interior doors and frames.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Remove welded-in shipping spreaders installed at factory. Restore exposed finish by grinding, filling, and dressing, as required to make repaired area smooth, flush, and invisible on exposed faces. Touch up factory-applied finishes where spreaders are removed.
- B. Drill and tap doors and frames to receive nontemplated, mortised, and surface-mounted door hardware.

3.2 INSTALLATION

- A. Install hollow-metal doors and frames plumb, rigid, properly aligned, and securely fastened in place. Comply with approved Shop Drawings and with manufacturer's written instructions.
- B. Hollow-Metal Frames: Comply with **ANSI/SDI A250.11**.

1. Set frames accurately in position; plumbed, aligned, and braced securely until permanent anchors are set. After wall construction is complete, remove temporary braces without damage to completed Work.
 - a. Where frames are fabricated in sections, field splice at approved locations by welding face joint continuously; grind, fill, dress, and make splice smooth, flush, and invisible on exposed faces. Touch-up finishes.
 - b. Install frames with removable stops located on secure side of opening.
 2. Fire-Rated Openings: Install frames according to NFPA 80.
 3. Floor Anchors: Secure with postinstalled expansion anchors.
 - a. Floor anchors may be set with power-actuated fasteners instead of postinstalled expansion anchors if so indicated and approved on Shop Drawings.
 4. Solidly pack mineral-fiber insulation inside frames.
 5. Masonry Walls: Coordinate installation of frames to allow for solidly filling space between frames and masonry with grout or mortar.
 6. In-Place Concrete or Masonry Construction: Secure frames in place with postinstalled expansion anchors. **Countersink anchors, and fill and make smooth, flush, and invisible on exposed faces.**
 7. Installation Tolerances: Adjust hollow-metal frames to the following tolerances:
 - a. Squareness: Plus or minus 1/16 inch (1.6 mm), measured at door rabbet on a line 90 degrees from jamb perpendicular to frame head.
 - b. Alignment: Plus or minus 1/16 inch (1.6 mm), measured at jambs on a horizontal line parallel to plane of wall.
 - c. Twist: Plus or minus 1/16 inch (1.6 mm), measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.
 - d. Plumbness: Plus or minus 1/16 inch (1.6 mm), measured at jambs at floor.
- C. Hollow-Metal Doors: Fit and adjust hollow-metal doors accurately in frames, within clearances specified below.
1. Non-Fire-Rated Steel Doors: Comply with **ANSI/SDI A250.8 guide specification indicated.**
 2. Fire-Rated Doors: Install doors with clearances according to NFPA 80.
 3. Smoke-Control Doors: Install doors according to NFPA 105.
- D. Glazing: Comply with installation requirements in Section 088000 "Glazing" and with hollow-metal manufacturer's written instructions.

3.3 FIELD QUALITY CONTROL

- A. Inspection Agency: **Owner may** qualified inspector to perform inspections and to furnish reports to Architect.
- B. Inspections:

1. Fire-Rated Door Inspections: Inspect each fire-rated door according to NFPA 80, Section 5.2.
 2. Egress Door Inspections: Inspect each door equipped with panic hardware, each door equipped with fire exit hardware, each door located in an exit enclosure, each electrically controlled egress door, and each door equipped with special locking arrangements according to NFPA 101, Section 7.2.1.15.
- C. Repair or remove and replace installations where inspections indicate that they do not comply with specified requirements.
- D. Reinspect repaired or replaced installations to determine if replaced or repaired door assembly installations comply with specified requirements.
- E. Prepare and submit separate inspection report for each fire-rated door assembly indicating compliance with each item listed in **[NFPA 80]** **[and]** **[NFPA 101]**.

3.4 REPAIR

- A. Prime-Coat Touchup: Immediately after erection, sand smooth rusted or damaged areas of prime coat and apply touchup of compatible air-drying, rust-inhibitive primer.
- B. Metallic-Coated Surface Touchup: Clean abraded areas and repair with galvanizing repair paint according to manufacturer's written instructions.
- C. Factory-Finish Touchup: Clean abraded areas and repair with same material used for factory finish according to manufacturer's written instructions.
- D. Touchup Painting: Cleaning and touchup painting of abraded areas of paint are specified in painting Sections.

END OF SECTION 081113

SECTION 08 1423 - PLASTIC FACED WOOD DOORS

PART 1 - GENERAL

1.1 ACTIONS SUBMITTALS:

- A. Product data: Submit manufacturer's product description, indicating materials, classifications, factory finish and fabrication. Include manufacturer's proposed warranty. Indicate that doors meet specified requirements, including fire ratings. Include manufacturer's requirements for door installation, finishing, care, maintenance and cleaning to obtain specified warranties.
- B. Shop drawings: Submit schedules and elevations indicating door sizes, construction, swing, fire rating, undercut, and hardware locations. Indicate that doors meet specified requirements, including fire ratings.

1.2 INFORMATIONAL SUBMITTALS:

- A. Intent to warrant and certifications: Submit an Intent to Warrant executed by authorized representative of door manufacturer, indicating that manufacturer has reviewed drawings and specifications, conditions affecting the work and the relationship of doors with related work, and that manufacturer proposes to provide warranties as referenced herein without further stipulation.

1.3 QUALITY ASSURANCE:

- A. Fire door assemblies:
 - 1. Door assemblies in rated walls shall have been tested in accord with NFPA 252 or UL 10C; after 5 minutes into NFPA 252 test, neutral pressure shall have been established at 40" or less above sill.
 - 2. Door assemblies in corridors and smoke barriers shall have a minimum fire rating of 20 minutes and shall have been tested in accord with NFPA 252 or UL 10C without hose stream test. Assemblies shall comply with UL 1784 for draft and smoke control test; leakage may not exceed 3.0 CFM per foot of door at 0.10" of water column.
 - 3. Fire-rated doors shall provide rating without use of salt-treated wood, or manufacturer shall provide certification that treated wood is non-hygroscopic and shall warrant door against failure or discoloration of face and door finish.
- B. Labeling requirements:
 - 1. On top edge, provide each door with a label which identifies manufacturer, trade association of which he is a member, grade and type of door or industry standard with which it complies.
 - 2. Fire-rated components shall bear factory-applied labels showing manufacturer's name, name of third-party inspection agency, fire-protection rating, and where required for doors in exit enclosures, maximum transmitted temperature end point. Permanently attach label to hinge stile of each fire-rated door.
 - 3. Smoke and draft doors complying with UL 1784 shall be labeled as a smoke and draft control door.
- C. All flush doors shall be the product of one manufacturer.
- D. Applicable standards; as referenced herein:
 - 1. American National Standards Institute (ANSI).
 - 2. American Society for Testing and Materials (ASTM).
 - 3. Architectural Woodwork Institute (AWI), "Architectural Woodwork Quality Standards, Guide Specifications and Quality Certification Program," October 1, 2014, 2nd Edition, herein referred to as AWI Standards. Work shall comply with applicable portions of AWI standards.
 - 4. Hardwood Plywood and Veneer Association (HPVA).

5. National Fire Protection Association (NFPA).
6. Underwriters Laboratories, Inc., (UL).
7. Window and Door Manufacturer's Association (WDMA).

1.4 DELIVERY, STORAGE AND HANDLING:

- A. Deliver no doors to building until weatherproof storage space is available. Store doors in a space having controlled temperature and humidity. Stack doors flat, off floor, supported to prevent warpage and protected from damage and direct exposure to sunlight.
- B. Seal top and bottom edges of doors, if required by manufacturer's product data to maintain warranty.
- C. Protect doors during shipping and storage by enclosing in polyethylene bags. Replace doors in original packaging for shipment to site following machining and finishing. Hang pre-machined and prefinished doors without removal of packaging. Identify each door with door number on packaging. Maintain packaging in place until Date of Substantial Completion.
- D. Break packaging seal on site to permit ventilation.
- E. Do not walk or stack other materials on top of stacked doors. Do not drag doors across each other.

1.5 WARRANTIES:

- A. Provide manufacturer's door replacement warranty against warpage, twist, delamination, telegraphing of core and manufacturing defects for the following terms:
 1. Interior solid core and mineral core doors: Lifetime of original installation.

PART 2 - PRODUCTS

2.1 DOORS:

- A. Acceptable manufacturers include, but are not necessarily limited to following; subject to compliance with specified requirements:
 1. Basis of design; Eggers Industries, Inc., a div. of VT Industries, Inc.
 2. Doormerica.
 3. Marshfield-Algoma, a Masonite Architectural Brand
 4. Oshkosh Door Co.
 5. VT Industries, Inc.
- B. General quality standard:
 1. Performance grade: Extra heavy duty.
 2. Aesthetic grades: WDMA I. S. 1-A or AWS, Section 9, Custom Grade.
- C. Glued particleboard core wood doors: Eggers "Plastic Flush-Particle"; meeting AWS Standards, Section 9, three-ply construction, plastic laminate face, PC-HPDL-3, structural composite lumber core (SCLC).
 1. Thickness: 1-3/4".
 2. Adhesive bond: Type II or better for interior applications.
 - a. Adhesives shall not contain urea formaldehyde.
 3. Blocking: Top and bottom rail and lock stile blocking shall accommodate specified hardware, without through-bolting hardware.
 4. Core: Structural composite lumber (SCL) core doors, meeting AWS SLC, structural composite lumber core.
 5. Construction: Hardwood stiles and rails glued to core; core assembly sanded for uniform thickness.

6. Crossbanding: Engineered high density fiberboard (HDF), minimum 1/16" thickness.
 7. Fire resistance rating: Comply with specified requirements for tested, labeled door construction for ratings indicated on drawings. Doors shall be constructed to 20 minute label requirements but label not required.
- D. Twenty-Minute Label: Eggers "20 MIN-SINGLE", twenty minute label, UL listed fire door, 1-3/4 inch thick with same faces and finish as solid core doors.
1. Core: ANSI A208.1, LD2 grade mat-formed particleboard, made with binder containing no urea-formaldehyde resin.
 2. Fire resistance rating: Comply with specified requirements for tested, labeled door construction for ratings indicated on drawings.
 3. Where rated door pairs require metal astragal for labeled construction, astragals shall be wrapped in veneer matching door face or concealed within door edge.
- E. PL-1; Plastic laminate facing manufacturers include, but are not necessarily limited to following; subject to compliance with specified requirements:
1. Acceptable products:
 - a. Formica Corp., Formica.
 - b. Nevamar Corp., Nevamar.
 - c. PL-1 Basis of design; WilsonArt International, Inc.
 2. Type: Nominal 0.050" thickness, general purpose type, high pressure decorative laminate conforming to NEMA Standard LD 3-2005, Grade HGL. Provide UL tested and labeled laminates to comply with fire protection labeled door construction requirements for labeled doors. Laminate faces shall be applied in one piece.
 - a. PL-1; Color: Asian Night 7949K-18. Grain to run vertically.
 3. Stiles for plastic laminate-faced doors: Minimum 1-3/8" wide by thickness of core with close grained solid hardwood or structural composite lumber inner stile backer with not less than outermost 1/4" of stile being close grained hardwood matching grain and color of plastic laminate door face; no exposed fingerjoints allowed. Fire-rated doors shall have treated hardwood or lamination as required for labeled construction.
 4. Blocking on Fire-Rated Doors:
 - a. Material: Reinforced, treated wood or high density composition material with hardwood facing accepting full mortise hinge installation.
 - 1) 600 lb. screw withdrawal resistance in compliance with ASTM D1037.
 - 2) 750 lb. average splitting resistance in compliance with ASTM D143.
 - b. Blocking: Provide special top and bottom rail lock stile blocking to accommodate specified hardware. Provide fire retardant treated blocking in head of fire rated doors to receive closers and provide fire retardant treated strip in middle of fire rated doors to receive panic devices. Do not thru-bolt.

2.2 FACTORY FITTING, MACHINING AND FINISHING:

- A. Factory fitting and machining and finishing are required for all wood doors.
- B. Fitting and machining:
1. Factory fit and machine doors to clearances and bevels specified.
 2. Prepare for hardware installation using hardware manufacturer's templates.
 - a. Locate in accord with WDMA I. S. 1.7, unless otherwise indicated.
 - b. Drill pilot holes for screws and bolts.
 3. Seal edges of doors and cutouts immediately following fitting and machining.
- C. Clearances and bevel:
1. Hinge stile: 1/8".
 2. Lock stile: 1/8".
 3. Top: 1/8".

4. Bottom: 1/4" above floor finish or threshold, except where undercutting is indicated. Confirm installed floor covering thickness before cutting door bottom edges.
5. Meeting stiles, pairs of doors: 1/8".
6. Bevel: 1/8" in 2".

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. Acclimatization: Allow doors to become acclimated to finished space conditions a minimum of 72 hours before hanging.
- B. Preparation: Verify that framed openings are installed within specified tolerances. Do not install doors in frames which are not installed within size and plumb tolerances.
- C. Installation:
 1. Install doors in accord with manufacturer's product data using scheduled hardware. Install using threaded-to-the-head wood screws furnished by hardware manufacturer.
 2. Anchor hardware in correct position and alignment.
 3. Adjust hardware and door for proper function and for smooth, free operation, latching without force or excess clearance, within specified clearances and tolerances.
- D. Fire-rated doors: Install in accord with UL requirements and NFPA No. 80-92 and No. 105-93. Refer to Drawings for rating requirements.
- E. Erection tolerances:
 1. Variation from specified clearances: +1/32", -0".
 2. Maximum variation in edge alignment, pairs of doors: 1/16".
- F. Replace doors with defects in material, finish, fit or machining.

END OF SECTION

SECTION 08 3113 - ACCESS DOORS AND PANELS

PART 1 - GENERAL

1.1 SUMMARY:

- A. Section includes access doors and frames for walls and ceilings.

1.2 ACTION SUBMITTALS:

- A. Product data: Indicate material types, finishes and sizes, fabrication and installation details and requirements.
- B. Product Schedule: Provide complete access door and frame schedule, including types, locations, sizes, latching or locking provisions, and other data pertinent to installation.

1.3 QUALITY ASSURANCE:

- A. Applicable standards; standards of the following, as referenced herein:
 - 1. American Iron and Steel Institute (AISI).
 - 2. ASTM International (ASTM).
 - 3. National Fire Protection Association (NFPA), National Fire Codes.
- B. Labeling requirements:
 - 1. Fire-rated access door assemblies shall bear factory-applied labels showing name of manufacturer, name of third-party inspection agency, fire-protection rating, and where required for access doors in exit enclosures, maximum transmitted temperature end point.
 - 2. Horizontal access doors shall bear a label that includes the wording "FOR HORIZONTAL INSTALLATION".
 - 3. Permanently attach label to each door and frame.

1.4 DELIVERY, STORAGE AND HANDLING:

- A. Deliver access doors in protective packaging.
- B. Store in packaging to prevent soiling and physical damage.
- C. Handle to prevent damage to finished surfaces and operating mechanisms.

1.5 PROJECT/SITE CONDITIONS:

- A. Protection: Protect prefinished surfaces from damage or staining. Following installation, provide protective covering for duration of project.
- B. Coordinate installation of access doors required to be built into building structure. Secure templates or lay out to rough dimensions provided by specialty manufacturer.

PART 2 - PRODUCTS

2.1 ACCESS DOORS AND PANELS:

- A. Acceptable manufacturers; subject to compliance with specified requirements:
 - 1. Activar Construction Products Group, Inc., J. L. Industries.
 - 2. Acudor Products, Inc.
 - 3. Babcock Davis Hatchways.
 - 4. Karp Associates, Inc.
 - 5. Nystrom.
- B. Characteristics:
 - 1. Size: As indicated on drawings.

2. Types:
 - a. Typical: As required by substrates.
 - b. Non-fire-rated access doors in gypsum board work: Flush type with perforated frame flanges for finishing with joint compound.
3. Construction:
 - a. Non-fire-rated units: Minimum 14 ga. steel sheet for doors; 16 ga. for frames; prime painted.
 - b. Stainless steel units: AISI Type 302/304 stainless steel; minimum 14 ga. for doors, 16 ga. for frames. Install stainless steel units where exposed in toilet rooms.
 - c. Fire-rated units: Minimum 22 ga. steel inside and outside faces; box construction, filled with insulation; 16 ga. frames; prime painted.
4. Hardware:
 - a. Provide flush, screwdriver-operated, cam type locks as required for panel size.
 - b. Where shown or scheduled, provide 1 cylinder lock per access door. Furnish 2 keys per lock and key all locks alike, unless otherwise scheduled.

PART 3 - EXECUTION

3.1 PREPARATION:

- A. Coordination:
 1. Coordinate installation of access doors required to be built into building structure. Secure templates or lay out to rough dimensions provided by specialty manufacturer.
 2. Ensure that access door orientation and fire ratings comply with fire ratings indicated on drawings.
 3. Coordinate with mechanical and plumbing sizes and locations of access doors.
 4. Coordinate access door types with final finish of adjacent wall.

3.2 INSTALLATION:

- A. Install access doors in accord with manufacturer's product data, plumb, level and true to line and location.
- B. Install access doors with fasteners of type and spacing recommended by manufacturer's product data.
- C. Set fire rated access doors at locations and elevations indicated and in accord with NFPA 80. Attach curb flange to floor/ceiling structure.
- D. Protect surfaces from damage or staining. Clean surfaces prior to Date of Substantial Completion.
- E. Test and adjust hardware for ease of operation.

END OF SECTION

SECTION 083323 - OVERHEAD COILING DOORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

- 1. Service doors.

- B. Related Requirements:

- 1. Section 055000 "Metal Fabrications" for miscellaneous steel supports, door-opening framing, corner guards, and bollards.
 - 2. **[Section 099113 "Exterior Painting"] [and] [Section 099123 "Interior Painting"]** for finish painting of factory-primed doors.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type and size of overhead coiling door and accessory.

- 1. Include construction details, material descriptions, dimensions of individual components, profiles for slats, and finishes.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished accessories.
 - 3. Include description of automatic-closing device and testing and resetting instructions.

- B. Shop Drawings: For each installation and for special components not dimensioned or detailed in manufacturer's product data.

- 1. Include plans, elevations, sections, and mounting details.
 - 2. Include details of equipment assemblies, and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include points of attachment and their corresponding static and dynamic loads imposed on structure.

4. For exterior components, include details of provisions for assembly expansion and contraction and for excluding and draining moisture to the exterior.
 5. Show locations of controls, locking devices and other accessories.
 6. Include diagrams for power, signal, and control wiring.
- C. Samples for Initial Selection: Manufacturer's finish charts showing full range of colors and textures available for units with factory-applied finishes.
1. Include similar Samples of accessories involving color selection.
- D. Samples for Verification: For each type of exposed finish on the following components, in manufacturer's standard sizes:
1. Curtain slats.
 2. Bottom bar.
 3. Guides.
 4. Brackets.
 5. Hood.
 6. Locking device(s).
 7. Include similar Samples of accessories involving color selection.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For **Installer and testing and inspecting agency**.
1. Fire-Rated Door Inspector: Submit documentation of compliance with NFPA 80, section 5.2.3.1.
 2. Submit copy of DHI Fire and Egress Door Assembly Inspector (FDAI) certificate.
- B. Oversize Construction Certification: For door assemblies required to be fire-rated and that exceed size limitations of labeled assemblies.
- C. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Special warranty.
- B. Maintenance Data: For overhead coiling doors to include in maintenance manuals.
- C. Record Documents: For fire-rated doors, list of door numbers and applicable room name and number to which door accesses.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer for both installation and maintenance of units required for this Project.
 - 1. Maintenance Proximity: Not more than **two** (2) hours' normal travel time from Installer's place of business to Project site.
- B. Fire-Rated Door Inspector Qualifications: Inspector for field quality control inspections of fire-rated door assemblies shall meet the qualifications set forth in NFPA 80, section 5.2.3.1 and the following:
 - 1. Door and Hardware Institute Fire and Egress Door Assembly Inspector (FDAI) certification.

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of doors that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: two (2) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Source Limitations: Obtain overhead coiling doors from single source from single manufacturer.
 - 1. Obtain operators and controls from overhead coiling-door manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. Fire-Rated Door Assemblies: Complying with NFPA 80; listed and labeled by qualified testing agency, for fire-protection ratings indicated, based on testing at as close to neutral pressure as possible according to **NFPA 252**.
 - 1. Oversize Fire-Rated Door Assemblies: For units exceeding sizes of tested assemblies, provide certification by a qualified testing agency that doors comply with standard construction requirements for tested and labeled fire-rated door assemblies except for size.
- B. Sound-Control Doors: Assemblies tested in a laboratory for sound-transmission-loss performance according to ASTM E90, calculated according to ASTM E413, and rated for not less than the STC value indicated.

- C. Structural Performance, Exterior Doors: Capable of withstanding the following design wind loads:
 - 1. Design Wind Load: **of 20 lbf/sq. ft. (960 Pa), acting inward and outward.**
 - 2. Deflection Limits: Design overhead coiling doors to withstand design wind load without evidencing permanent deformation or disengagement of door components.
 - 3. Operability under Wind Load: Design overhead coiling doors to remain operable under **velocity pressure of 20-lbf/sq. ft.** wind load, acting inward and outward.
- D. Seismic Performance: Overhead coiling doors shall withstand the effects of earthquake motions determined according to **ASCE/SEI 7.**
 - 1. Component Importance Factor: **1.0.**

2.3 DOOR ASSEMBLY

- A. **Service** Door: Overhead coiling door formed with curtain of interlocking metal slats.
- B. Operation Cycles: Door components and operators capable of operating for not less than **10,000** . One operation cycle is complete when a door is opened from the closed position to the fully open position and returned to the closed position.
 - 1. Include tamperproof cycle counter.
- C. STC Rating: **26.**
- D. Door Curtain Material: **Galvanized steel.**
- E. Door Curtain Slats: **Flat** profile slats of **2-5/8-inch (67-mm)** center-to-center height.
 - 1. Gasket Seal. Manufacturer's standard continuous gaskets between slats.
- F. Bottom Bar: Two angles, each not less than **[1-1/2 by 1-1/2 by 1/8 inch]** ; fabricated from **[hot-dip galvanized steel]** and finished **to match door.**
- G. Curtain Jamb Guides: **Galvanized steel** with exposed finish matching curtain slats.
- H. Locking Devices: Equip door with **locking device assembly.**
 - 1. Locking Device Assembly: [locking bars, operable from **inside and outside with cylinders.**
- I. Manual Door Operator: **Manufacturer's standard crank operator.**
 - 1. Control Station(s): **Interior mounted.**
- J. Curtain Accessories: Equip door with **weatherseals.**

K. Door Finish:

1. Aluminum Finish: **Anodized color as selected by Architect from full range of industry colors and color densities.**

L. complete when a door is opened from the closed position to the fully open position and returned to the closed position.

1. Include tamperproof cycle counter.

M. Manual Door Operator: **Chain-hoist operator.**

N. Curtain Accessories: Equip door with smoke seals, automatic-closing device, **push/pull handles, pull-down strap, poll hook.**

O. Door Finish:

1. Baked-Enamel or Powder-Coated Finish: **[Color as indicated by manufacturer's designations. Color as selected by Architect from manufacturer's full range.**
2. Factory Prime Finish: Manufacturer's standard color.
3. Interior Curtain-Slat Facing: **Match finish of exterior curtain-slat face.**

2.4 MATERIALS, GENERAL

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.5 DOOR CURTAIN MATERIALS AND CONSTRUCTION

- A. Door Curtains: Fabricate overhead coiling-door curtain of interlocking metal slats, designed to withstand wind loading indicated, in a continuous length for width of door without splices. Unless otherwise indicated, provide slats of thickness and mechanical properties recommended by door manufacturer for performance, size, and type of door indicated, and as follows:

1. Steel Door Curtain Slats: Zinc-coated (galvanized), cold-rolled structural-steel sheet; complying with ASTM A653/A653M, with G90 (Z275) zinc coating; nominal sheet thickness (coated) of 0.028 inch (0.71 mm); and as required.
2. Insulation: Fill slats for insulated doors with manufacturer's standard thermal insulation complying with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, according to ASTM E84 or UL 723. Enclose insulation completely within slat faces.
3. Metal Interior Curtain-Slat Facing: Match metal of exterior curtain-slat face, with **[minimum steel thickness of 0.010 inch (0.25 mm)] [and] [minimum aluminum thickness of 0.032 inch (0.80 mm)].**

- B. Curtain Jamb Guides: Manufacturer's standard angles or channels and angles of same material and finish as curtain slats unless otherwise indicated, with sufficient depth and strength to retain curtain, to allow curtain to operate smoothly, and to withstand loading. Slot bolt holes for guide adjustment. Provide removable stops on guides to prevent overtravel of curtain[, **and a continuous bar for holding windlocks**].
 - 1. Locking Hardware:
 - a. **As selected by Architect from manufacturer's full range.**
 - b. Lock Cylinders: As [specified in Section 087100 "Door Hardware"] [specified in Section 087111 "Door Hardware (Descriptive Specification)"] [standard with manufacturer] [and keyed to building keying system].
 - c. Keys: [Two] [Three] <Insert number> for each cylinder.
 - 2. Thresholds: Equip pass doors with integral thresholds that comply with the accessibility standard of authorities having jurisdiction.

2.6 HOODS

- A. General: Form sheet metal hood to entirely enclose coiled curtain and operating mechanism at opening head. Contour to fit end brackets to which hood is attached. Roll and reinforce top and bottom edges for stiffness. Form closed ends for surface-mounted hoods and fascia for any portion of between-jamb mounting that projects beyond wall face. Equip hood with intermediate support brackets as required to prevent sagging.
 - 1. Galvanized Steel: Nominal 0.028-inch- (0.71-mm-) thick, hot-dip galvanized-steel sheet with G90 (Z275) zinc coating, complying with ASTM A653/A653M.
- B. Removable Metal Soffit: Formed or extruded from same metal and with same finish as curtain if hood is mounted above ceiling unless otherwise indicated.

2.7 LOCKING DEVICES

- A. Slide Bolt: Fabricate with side-locking bolts to engage through slots in tracks for locking by padlock, located on both left and right jamb sides, operable from coil side.
- B. Locking Device Assembly: Fabricate with cylinder lock, spring-loaded dead bolt, operating handle, cam plate, and adjustable locking bars to engage through slots in tracks.
 - 1. Lock Cylinders: As **standard with manufacturer] and keyed to building keying system.**
 - 2. Keys: **Three** for each cylinder.
- C. Chain Lock Keeper: Suitable for padlock.

2.8 CURTAIN ACCESSORIES

2.9 COUNTERBALANCE MECHANISM

- A. General: Counterbalance doors by means of manufacturer's standard mechanism with an adjustable-tension, steel helical torsion spring mounted around a steel shaft and contained in a spring barrel connected to top of curtain with barrel rings. Use grease-sealed bearings or self-lubricating graphite bearings for rotating members.
- B. Counterbalance Barrel: Fabricate spring barrel of manufacturer's standard hot-formed, structural-quality, **[seamless] [or] [welded]** carbon-steel pipe, of sufficient diameter and wall thickness to support rolled-up curtain without distortion of slats and to limit barrel deflection to not more than 0.03 in./ft. (2.5 mm/m) of span under full load.
- C. Counterbalance Spring: One or more oil-tempered, heat-treated steel helical torsion springs. Size springs to counterbalance weight of curtain, with uniform adjustment accessible from outside barrel. Secure ends of springs to barrel and shaft with cast-steel barrel plugs.
- D. Torsion Rod for Counterbalance Shaft: Fabricate of manufacturer's standard cold-rolled steel, sized to hold fixed spring ends and carry torsional load.
- E. Brackets: Manufacturer's standard mounting brackets of either cast iron or cold-rolled steel plate.

2.10 MANUAL DOOR OPERATORS

- A. General: Equip door with manual door operator by door manufacturer.
- B. Push-up Door Operation: Lift handles and pull rope for raising and lowering doors, with counterbalance mechanism designed so that required lift or pull for door operation does not exceed **25 lbf (111 N)**.
- C. Chain-Hoist Operator: Consisting of endless steel hand chain, chain-pocket wheel and guard, and gear-reduction unit with a maximum **25-lbf (111-N)** force for door operation. Provide alloy-steel hand chain with chain holder secured to operator guide.

2.11 GENERAL FINISH REQUIREMENTS

- A. Comply with NAAMM/NOMMA 500 for recommendations for applying and designating finishes.
- B. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.12 ALUMINUM FINISHES

- A. Mill Finish: Manufacturer's standard.
- B. Clear Anodic Finish: AAMA 611, **AA-M12C22A41, Class I, 0.018 mm** or thicker.
- C. Color Anodic Finish: AAMA 611, **[AA-M12C22A42/A44, Class I, 0.018 mm** or thicker.
- D. Baked-Enamel or Powder-Coat Finish: AAMA 2603. Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.

2.13 STEEL AND GALVANIZED-STEEL FINISHES

- A. Factory Prime Finish: Manufacturer's standard primer, compatible with field-applied finish. Comply with coating manufacturer's written instructions for cleaning, pretreatment, application, and minimum dry film thickness.
- B. Baked-Enamel or Powder-Coat Finish: Manufacturer's standard baked-on finish consisting of prime coat and thermosetting topcoat. Comply with coating manufacturer's written instructions for cleaning, pretreatment, application, and minimum dry film thickness.
- C. Bright, Cold-Rolled, Unpolished Finish: ASTM A480/A480M No. 2B.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates areas and conditions, with Installer present, for compliance with requirements for substrate construction and other conditions affecting performance of the Work.
- B. Examine locations of electrical connections.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install overhead coiling doors and operating equipment complete with necessary hardware, anchors, inserts, hangers, and equipment supports; according to manufacturer's written instructions and as specified.
- B. Install overhead coiling doors, hoods, controls, and operators at the mounting locations indicated for each door.

- C. Accessibility: Install overhead coiling doors, switches, and controls along accessible routes in compliance with the accessibility standard.

3.3 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections **with the assistance of a factory-authorized service representative**:
 - 1. Test door release, closing, and alarm operations when activated by smoke detector or building's fire-alarm system. Test manual operation of closed door. Reset door-closing mechanism after successful test.
 - 2. Fire-Rated Door Inspections: Inspect each fire-rated door in accordance with NFPA 80, section 5.2.
- B. Repair or remove and replace installations where inspections indicate that they do not comply with specified requirements.
- C. Reinspect repaired or replaced installations to determine if replaced or repaired door assembly installations comply with specified requirements.
- D. Prepare and submit separate inspection report for each fire-rated door assembly indicating compliance with each item listed in **NFPA 80**.

3.4 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. After electrical circuitry has been energized, operate doors to confirm proper motor rotation and door performance.
 - 3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

3.5 ADJUSTING

- A. Adjust hardware and moving parts to function smoothly so that doors operate easily, free of warp, twist, or distortion.
 - 1. Adjust exterior doors and components to be weather resistant.
- B. Lubricate bearings and sliding parts as recommended by manufacturer.
- C. Adjust seals to provide tight fit around entire perimeter.

3.6 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include **12** months' full maintenance by skilled employees of coiling-door Installer. Include **quarterly** preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper door operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
1. Perform maintenance, including emergency callback service, during normal working hours.
 2. Include 24-hour-per-day, seven-day-per-week, emergency callback service.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain overhead coiling doors.

END OF SECTION 083323

SECTION 084000 – VERTICALLY BI-FOLD HANGER DOOR

1. QUANTITY
 - 1.1 Doors for this project will consist of (1) bi-fold doors
2. SIZE OF DOOR - Clear Open Width & Height
 - 2.1 Hanger door with door in up position, shall have a minimum clear opening width of (X' X") as shown in the plans and a minimum clear height of (X' X") above finished floor elevation.
3. PLACEMENT of the Bi-Fold Door unto the building
 - 3.1 Door shall be mounted flush with exterior walls of building.
4. GENERAL / CONTRACTORS REQUIREMENTS: - DESIGN CRITERIA
 - 4.1 The bi-fold hangar doors shall be designed to the same loading requirements for live, dead and wind loads as the hangar building.
 - 4.2 The doors shall be engineered to resist all anticipated loads without sagging, bowing or conflicting with its smooth and efficient operation.
 - 4.3 The design shall be furnished, approved and sealed by a professional engineer registered in the state where the project is located.
 - 4.4 The building header shall be designed to accommodate horizontal and vertical building deflections to support the bi-fold door in all positions (with the proper lateral bracing).
 - 4.5 The building's door columns shall be framed of the proper design and size to reinforce the opening (with lateral bracing) and to carry all loads and vibrations imposed thereon.
 - 4.6 The Bi-fold should have solid footing with sill directly underneath the door frame and extending outward from the door to provide a base for the door's weather seal. This also prevents flow of water into, or under, the door installation.
 - 4.7 The finished floor of the building should be designed to prevent flow of water under the door installation. Sills shall have a slight slope outward of the bi-fold door to prevent water flow under the door installation.
5. GENERAL / ELECTRICAL REQUIREMENTS:
 - 5.1 The building contractor shall furnish and install a prewired electrical door operating mechanism to control each bi-fold door.
 - 5.2 The contractor is responsible and required to completely install the prewired electrical door operating mechanism, push button controls, devices and electrical conduit and wiring to the door operating controls.
 - 5.3 The electrical door mechanism and control shall be field wired by the contractor (Not The Door Manufacturer)
 - 5.4 Control panel with up/down/off switch pre-wired to motor, and over-ride controls with the required number of adequately sized insulated electrical conductors.
6. GENERAL / Electric Power Operator: For the Bi-Fold Doors
 - 6.1 All electrical controls and devices shall conform to the requirements of the current National Electrical Code 513, NEMA, and be UL approved.
 - 6.2 Provide UL Listed Electric Operator, size and type as recommended by the manufacturer.
 - 6.3 The operator is furnished complete and consists of a motor and factory-wired control panels consisting of main fused disconnect switch, magnetic reversing starters, limit switches and push button controls, control circuit transformers, relays, timing devices, and warning devices.
7. SUBMITTALS
 - 7.1 Product Data: Submit manufacturer's A1, A2, A3 Spec Sheets for each Bi-fold Door, plus product data and installation instructions. Include details of construction relative to materials, dimensions of individual components, profiles, and finishes. Provide roughing-in diagrams. Include the following:
 - A. Summary of forces and loads on walls and jambs.
 - B. Setting drawings, templates, and installation instructions for built-in or embedded anchor devices.
 - 7.2 Shop Drawings: Submit shop drawings for approval prior to fabrication. Include detailed plans, elevations, details of framing members, required clearance, anchors and accessories. Include relationship with adjacent materials. The make and type of door, operators and controls shall be clearly shown. Door weight, method of suspension, operation, and all fastenings shall be indicated.

- 7.3 Submit () copies each of the following manufacturer's Manuals / Diagrams
- A. Bi-Fold Door Literature
 - B. Installation Manual
 - C. Operating Instructions
 - D. Maintenance data/manual.
 - E. Safety Decal Placement Guide Manual / Warning Labels
 - F. Electrical System Manual for the bi-fold door system
 - 1) Electrical Schematics
 - 2) Electrical Wiring Diagram
 - G. Diagram's of potentially hazardous locations related to the operation of the door.
 - H. Shop drawings for approval.
- 7.4 Submit shop drawings specific for this project.
NOTE: Generalized project drawings not specific to this project will not be acceptable
8. QUALITY ASSURANCE
- 8.1 Source Limitations: Obtain Bi-Fold doors through one source from a single manufacturer.
 - 8.2 Manufacturer Qualifications: Engage a firm experienced in manufacturing Bi-Fold doors similar to those indicated for this Project and with a record of successful in-service performance.
 - 8.3 Installer Qualifications: Engage an experienced installer who is an authorized representative of the door manufacturer for both installation and maintenance of units required for this Project.
 - 8.4 Product Options: Drawings indicate size, profiles, and dimensional requirements of Bi-Fold doors and accessories. Other manufacturers' systems with equal performance and dimensional characteristics may be considered. Refer to OPTIONAL UPGRADE EQUIPMENT.
 - 8.5 Pre-Installation Conference: Schedule a pre-installation conference prior to commencement of field operations that might affect installation of bi-fold doors to establish procedures for maintaining optimum working conditions, and to coordinate this work with related and adjacent work.
 - 8.6 The contractor shall touch up all scratches, abrasions or other slight painting defects with the same type and color of paint as originally applied.
9. DELIVERY, STORAGE AND HANDLING
- 9.1 Deliver materials and products in manufacturer's labeled protective packages. Store and handle in strict compliance with manufacturer's written instructions and recommendations. Protect from damage from weather, excessive temperatures and constructions operations.
 - 9.2 Inspect vertical bi-fold doors upon delivery for damage. Minor damages may be repaired provided refinished items are equal in all respects to new work and acceptable to Architect. Otherwise, remove and replace damaged items as directed.
 - 9.3 Place bi-fold door frame units on minimum 4" high wood blocking. Store doors components & Packages at building site under cover. Avoid use of non-vented plastic or canvas shelters which could create humidity chamber. If cardboard wrapper on door becomes wet, remove carton immediately.
 - 9.4 The contractor shall store the sheet, panels, components and other manufactured items so that they will not be damaged or deformed. Store metal sheets or panels so that water accumulations will drain freely. Do not store sheets or panels in contact with other materials which might cause staining.
10. APPROVED MANUFACTURER'S
- 10.1 The bi-fold doors supplied by a manufacturer who is regularly engaged in the manufacture of aircraft hangar doors for a minimum of ten years, and upon request from the owner provide a list of completed projects. Bi-fold door shall be as manufactured by Schweiss Bi-Fold Doors, Box 220, Fairfax, Mn 55332, Phone 507-426-8273 or approved equal.
 - A. Schweiss Bi-Fold Doors
P.O. Box 220
Fairfax, MN. 55332 Phone 507-426-8273 Fax 507-426-7408
 - B.
 - 10.2 Other manufacturer's seeking approval of their products must comply with requirements of the Instructions to Bidders.

11. BI-FOLD DOOR FRAMEWORK- FABRICATION / CONSTRUCTION REQUIREMENTS

- 11.1 Hangar doors shall be of the electrically operated bi-fold canopy type and shall be integral with the hangar building design.
- 11.2 When in the open position the doors shall have a slight slope to direct drainage away from the building.
- 11.3 Door shall be hinged horizontally at the top and center, and be arranged to open by moving frame out & up.
- 11.4 Door frames shall have prelocated top hinges to align with the building truss members.
- 11.5 Door shall be self contained with only the top hinges, bottom door rollers and column followers/ wind rails.
- 11.6 The door framework shall consist of jig welded steel tube sections engineered by the door manufacturer to resist all anticipated loads without sagging, bowing or conflicting with its smooth operation.
- 11.7 Structural steel door framing members shall be ASTM A500 Grade B square structural welded steel tubing.
- 11.8 All labor, materials, accessories, equipment and services necessary to furnish a complete installation of a bi-fold hangar door as indicated by the manufacturer. Including frame, sections, brackets, guides, tracks, hardware, operators and installation instructions.
- 11.9 Shop connections shall be welded.
- 11.10 Field connections shall be bolted.

12. DRIVESHAFT / LIFT DRUMS

- 12.1 The solid steel driveshaft with lift drums mounted on bottom cord of door runs continuously along entire door width providing an even lift of the door at all times.
- 12.2 The drive shaft shall be attached to the door frame with (greaseable) bearing mounts wherever there is a cable drum installed, to minimize stress on the shaft.
- 12.3 Solid Driveshaft and lift drums shall be in sufficient amount to give 5:1 safety factor.

13. LIFTING METHODS

- + 13.1 LIFT STRAPS
 - A. The door power unit shall be operated by a system of lifting straps (NOT CABLES), lifting drums and drive shafts
 - B. Lift Straps attached to a retainer on the upper door frame passing through a strap guide attached at the top chord of the door frame, thereby transmitting forces directly to header of building & relieving door of unnecessary stresses.
 - C. The Lift Straps shall have adjustable slack take-up device to keep proper tension on each Lift Strap.
 - D. The lift drums must be properly shielded to avoid any potential hazards to people.
 - E. Lift Straps and Lift Drums shall be manufacturer's standard adequately sized in sufficient amount to give 5:1 safety factor.

14. HEAVY DUTY HINGES

- 14.1 Heavy Duty Steel Hinges furnished complete. Each Hinge set shall be 10.50" wide, pins shall be 11/16" diameter minimum.

15. DOOR TRUSS'S

- + 15.1 INTERNAL TRUSS - STANDARD
 - A. An extra heavy duty center truss shall be installed in the center of the interior side.
 - B. There will be a truss at the base of the door to provide extra strength

16. HEAVY DUTY SIDE ROLLERS

- 16.1 The bi-fold hangar doors shall include 3" Heavy Duty minimum guide rollers with sealed bearings on bottom of door at jamb location.

17. COLUMN FOLLOWERS / WIND RAILS

- 17.1 System provided by the door manufacture to hold the base of the door securely against the building when the door is in the closed position.

- + A. Solid square columns secure only in the closed position = Wind Rails.

18. WIND PINS

- + 18.1 Automatic Wind Pins
 - A. Center wind pins 1" diameter minimum - provide a sturdy installation - Must automatically engage/disengage.

19. MANUAL LATCHING SYSTEM'S

- + 19.1 Standard Manual Latch - STANDARD
 - A. The latching system shall be provided on both sides of the doors.

- B. A manually latching system will be furnished so that the door is manually unlocked before the door can be opened and manually relocked after the door is in the closed position.
- 20. PAINT
 - 20.1 The door frame members and parts shall be factory primer finished with gray primer.
- 21. TOP & BOTTOM RUBBER SEALS
 - 21.1 Provide manufacturer's standard seal continuous at top, bottom of each door.
 - 21.2 The door shall be equipped with neoprene weather stripping at heads and jambs to prevent flow of moisture into the door installation. Sills shall have a special fabric reinforced high grade rubber astragal. The entire door perimeter shall be weather tight.
 - 21.3 Note: That existing bituminous surface varies and seals shall be placed accordingly.
- 22. Weather Seal - Kit
 - 22.1 The sides, and center of each bi-fold can be sealed off with a special weather stripping. The center of the door must have a self-sticking foam cushion seal. The entire door perimeter must be weather tight.
- 23. BI-FOLD DOOR ELECTRIC POWER OPERATOR --- BOTTOM DRIVE
 - 23.1 Location of Power Operator
 - A. Motor shall be located on bottom chord of door frame.
 - 23.2 Electrical Controls
 - A. All electrical controls and devices shall be designed to meet National Electrical Code Section 513.
 - B. All controls are pre-wired and factory tested.
- 24. ELECTRIC MOTOR / VOLTAGE / PHASE
 - 24.1 ELECTRIC MOTOR / VOLTAGE / PHASE - OPTION 1 - STANDARD
 - A. Service: 240 VAC, single phase, 3 wire service.
 - B. Single Phase Motor's shall be totally enclosed capacitor start.
 - C. Single phase, 240 volt electric motor with overload protection direct mounted to a gear reduction box and winding drum.
 - D. The size of the motor shall be as recommended by the manufacturer.
 - E. Door operator shall be pre-wired at factory complete with 24 V.A.C. control system.
- 25. Gear Motor
 - 25.1 The gear motor is equipped with an electric brake, which will stop and hold door in any position of door travel.
 - 25.2 Provide high starting torque, reversible, continuous duty, class A insulated, electric motors complying with NEMA MG 1, with overload protection, sized to start, accelerate, and operate door in either direction, from any position.
 - 25.3 A magnetic starter, with 24v control unit for reliability is standard.
 - 25.4 Design operator so motor may be removed without disturbing limit switch adjustment and without affecting emergency auxiliary operator.
- 26. CONTROL STATION'S - CHOOSE ONE
 - + 26.1 2 Button Constant Hold Control Station - for opening & closing your Bi-fold door.
 - A 2-button constant contact dead man switch, prevents operator from leaving control panel while door is in motion, either up or down.
 - B. When the operator takes his hand off the up /down button, the door immediately stops regardless of its opening / closing position.
 - C. The motor automatically stops when the door reaches either the full open or closed position.
- 27. Limit Switches
 - 27.1 Heavy duty limit switch box shall be weatherproof.
 - 27.2 Heavy duty limit switch box shall provide adjustable switches interlocked with motor controls and set to automatically stop door at fully opened and fully closed positions.
 - 27.3 Note: Safety edges shall not be used as limit switches.
- 28. ELECTRICAL DISCONNECT
 - 28.1 Provide Electrical Disconnect to completely disable the door, for service, maintenance emergency backup operations.
 - 28.2 Mount disconnect so it is accessible from floor level.
- 29. EXECUTION
 - 29.1 Examination

- A. Examine wall and overhead areas, including opening framing and blocking, with Installer present, for compliance with requirements for installation tolerances, clearances, and other conditions affecting performance of Work of this section.
 - B. Proceed with installation only after unsatisfactory conditions have been corrected.
30. INSTALLATION
- 30.1 General:
 - A. Door manufacturer is required to coordinate with the metal building manufacturer in the development of the exact installation details, and provide weights and door loadings to building manufacturer.
 - B. Install door, track, and operating equipment complete with necessary hardware, jamb and head mold strips, anchors, inserts, hangers, and equipment supports according to Shop Drawing, manufacturer's written instructions, and as specified.
 - C. Fasten vertical track assembly to framing at not less than 24 inches o.c. Hang horizontal track, hinges from structural overhead framing with angle or channel hangers welded and/or bolt fastened in place. Provide sway bracing, diagonal bracing, and reinforcement as required for rigid installation of track, hinges and door-operating equipment.
 - 30.2 Top and Bottom Limits Settings
 - A. Each bi-fold door has a recommended clear opening setting, specified by the manufacture. Do not over travel the door beyond the recommended setting.
 - 30.3 Exterior wall panels
 - A. Metal building erector to install the same exterior wall panels that are on the building, use the same type on the bi-fold doors. Install the proper trims that are recommended by the manufacturer.
 - 30.4 Apply Proper Safety Markings
 - A. Apply Proper Markings for any potentially hazardous locations related to the operation of the door.
 - B. Follow the pictorial diagram included in the door installation manual.
 - 30.5 Installing Warning Labels
 - A. Furnish warning labels for any potentially hazardous locations related to the operation of the door.
 - B. Fasten warning labels to the bi-fold door frame and by the operator's station in accordance with manufacturer's instructions, NO EXCEPTIONS.
 - + 30.6 Installer Certificates: Signed by manufacturer certifying that installers comply w/ specified requirements.
31. ELECTRICAL WORK - Contractor is responsible for:
- 31.1 The contractor is responsible and required to completely install the prewired electrical door operating mechanism, push button controls, devices and electrical conduit & wiring to the door operating controls.
 - 31.2 Detail wiring for power, signal, and control systems.
 - A. Differentiate between manufacturer-installed and field installed wiring & between components provided by door manufacturer and those provided by others.
 - 31.3 Install bi-fold doors in accordance with manufacturer's instructions.
32. Adjust & Clean
- 32.1 Lubricate, test adjust doors - to operate easily, free from warp, twist, or distortion and fitting weather tight for entire perimeter.
 - 32.2 Prime Coat Touch Up:
 - A. Immediately after erection, sand smooth any rusted or damaged areas of prime coat.
 - B. Touch-up damaged coating and finishes and repair minor damage.
 - C. Clean exposed surfaces using non-abrasive materials and methods recommended by manufacturer of material or product being cleaned, and apply touch up of compatible air drying primer.
 - 32.3 Final Adjustments:
 - A. Lubricate bearings and moving parts, adjust open and closed limits & doors to operate easily, free from warp, twist, or distortion and fitting weathertight for the entire perimeter.
 - B. Check and readjust operating finish hardware items, leaving vertical bi-fold doors undamaged and in complete and proper operating condition.
33. DEMONSTRATION
- 33.1 Startup Services: Engage a qualified -authorized service representative to perform startup services and to train Owner's maintenance personnel as specified below:
 - A. Test and adjust controls and safeties. Replace damaged and malfunctioning controls & equipment.

- B. Train Owner's maintenance personnel on procedures and schedules related to startup and shut down, operating , troubleshooting, servicing, and preventative maintenance.
- C. Review data in the installation & maintenance manuals.
- D. Schedule training with Owner at least 7 days advance notice.

34. WARRANTY

- 34.1 The Contractor shall warrant the door to be free of defects in accordance with the General Conditions, except the warranty shall be extended by manufacturer's 2 - year written warranty against defects in materials and workmanship, against problems which arise through normal anticipated usage of the door during the warranty period. The warranty shall be signed by the manufacturer.
- 34.2 Additional Warranty On The Straps
In addition to the warranty specified above, the door manufacturer shall warrant the original lift straps for a period of five years, against defects in material.

35. OPTIONAL UPGRADE EQUIPMENT

Note to Specifier: Select desired upgrade options below, and verify materials and insulation / application with the manufacturer; those related to door operating safety relative to danger to humans, and followed by an (R), may be required for your project; delete (R) in final text for those selected.

- 35.1 # 1 Top Override Safety Switches
Upper override switch that disconnects power to door if upper limit fails or if limits are overridden. This safety feature is designed to prevent the door from traveling beyond it's recommended clear opening height. If the door passes its full clear opening height, it will activate the override and stop the door automatically.
- 35.2 # 2 Side Latch Safety Switches
Side Latch Safety Switches eliminate possible damage if door is opened while in locked position. These switches are designed to prevent the door from operating while the side latches are locked in the closed position.
- 35.3 # 3 Warning Lights And Horn (R)
Warning Lights And Horn, which alerts persons in the area that door is opening or closing.

36. ACCESSORIES

- 36.1 QTY OF WALK IN DOOR
 - A Quantity of walk in doors in the Bi-Fold Door
- 36.2 LOCATION OF WALK IN DOOR
 - A Right Outside
 - B Left Outside
 - C Left and Right
- 36.3 WALK IN DOOR
 - A An insulated walk in door with minimum dimensions of 36 inches x 72 inches shall be provided in each bi-fold.
- 36.4 WALK IN DOOR WITH A WINDOW
 - A An insulated walk in door with minimum dimensions of 36 inches x 72 inches shall be provided in each bi-fold.
 - B The window within the walk door shall be 16" x 16"
- 36.5 WALK IN DOOR COLOR
 - A Standard color specified / provided by the door mfg
 - B Paint the walk in door to match the building
- 36.6 WALK IN DOOR CYLINDER LOCK
 - A. The walk-in door shall be equipped with a cylindrical lock and shall be master keyed, manufactured by Schlage, or approved equal.
 - B Each unit shall be keyed differently, however doors securing entry to the same room shall be keyed alike. Two individual keys shall be furnished for each hangar unit together with three master keys.
 - C Each walk in door will be pre-painted by the contractor to match metal building covering.
 - D Each Locking System may vary.
 - E For electrically operated bi-fold doors, equip man door with safety interlock switch which will prevent electric operation of bi-fold door when the man door is open or ajar.

37. WINDOWS

- 37.1 Windows shall be metal clad slider or casement windows with glass.
- 37.2 Windows shall be operable with removable insect screens.
- 37.3 Window Installation shall meet manufacturer's specifications.

Note to Specifier:

- 1-
 - 2-
 - 3-
 - 3.1 Will the door roll up the side columns on the building.
 - 3.2 This would be a special recessed fit --so the door sheeting and the building sheeting are in line
 - 4-
 - 4.3 Call out the: Wind loads for the area door will be installed
 - 5-
 - 6-
 - 6-
 - 8-
 - 9-
 - 10-
 - 11-
 - 12-
 - 13
 - 13.1 Select either standard aircraft cable system above or optional lift strap below.
 - 13.2 Select either standard aircraft cable system above or optional lift strap below.
 - 14-
 - 15-
 - 15.1 Internal truss is the most popular style -- neat clean looking
 - 15.2 External truss can be used on larger doors 70 ft and larger
 - 16-
 - 17-
 - 17.1 A The building should have I Beam -- to use our standard Column followers - select one
 - 17.1 B When building has solid sq columns -- We use wind rails in this application - select one
 - 18-
 - 18.1 All doors will have manual wind pins --unless you need or select automatic wind pins
 - 18.2 All doors will have manual wind pins --unless you need or select automatic wind pins
 - 19-
 - 19.1 Our Standard Latch
 - 19.2 Latch from one end of the door
 - 20-
 - 20.1 Fully automatic latchins system
 - 20.2 Used on Fully automatic latchins system - with remotes
May be necessary to add -- # 5 Warning Lights And Horn
 - 21-
 - 21.1 We can paint the doors any color -- standard is gray
 - 22-
 - 23-
 - 23.1 Weather Seal Kit is an option, but is highly recommended.
 - 24-
 - 24.1 Insulation may not be necessary, but may be provided; verify available materials with manufacturer.
 - 25-
 - 26-
 - 26.1 Liner panels are not necessary, but may be provided; verify available materials with manufacturer. -Bottom Only
 - 26.2 Liner panels are not necessary, but may be provided; verify available materials with manufacturer.-Both Halves
 - 27-
 - 28- Select the Proper Voltage and Phase need.
 - 29-
 - 30-
- Misc Items
- 00.1 Power outage Provide stand by generator to lower & raise the door.
 - 00.2 Select top drive lifting method above or bottom drive lifting method.

SECTION 08 4413 - ENTRANCES, CURTAIN WALL AND FIXED FRAMING

PART 1 - GENERAL

1.1 SUMMARY:

- A. Related work specified elsewhere:
 - 1. Concrete.
 - 2. Structural steel.
 - 3. Joint sealants.
 - 4. Glazing.
 - 5. Gypsum board.

1.2 DESIGN REQUIREMENTS:

- A. Wind load and resistance: Design framing system to withstand wind load pressures in accord with International Building Code, 2012 Edition with Amendments and ASCE 7.
 - 1. Wind loads for an ultimate wind speed of 150 mph 3-second gust.
 - 2. Exposure: Exposure B.
 - 3. Risk Category: III (ASCE 7 Method).
- B. Thermal movement: Completed curtain wall system shall be capable of withstanding expansion and contraction of components caused by an ambient air temperature range from -10°F. to + 150°F. without buckling, undue stress on glass, edge seal failure, excess stress on structural elements, damaging loads on anchors and fasteners reduction in performance or other detrimental defects.
- C. Static pressure air infiltration: Completed curtain wall (punched opening) shall have a maximum infiltration of 0.06 cfm/sq. ft. of fixed wall area at 6.24 psf when tested in accord with ASTM E283-04.
- D. Water penetration (static pressure): No uncontrolled water other than condensation on the indoor face of any curtain wall (punched opening) component when tested in accord with ASTM E331-00(2009), with differential static pressure equal to 20% of the inward acting design wind load pressure but not less than 10 psf.
- E. Water penetration (dynamic pressure): No uncontrolled water other than condensation shall occur on the indoor face of any curtain wall (punched opening) member when tested in accord with AAMA 501.1.
- F. Structural performance:
 - 1. Complete curtain wall (punched opening) system shall withstand positive and negative wind pressure loading of 40 psf; loads acting perpendicular to wall plane. Test per ASTM E330-02, Procedure. There shall be no deflection in excess of L/175 of the span of any framing member at design load. At structural test load equal to 1.5 times the specified design load, no glass breakage or permanent set in the framing members in excess of 0.2% of their clear spans shall occur.
 - 2. Deflection limitations and testing requirements:
 - a. Maximum allowable deflection of curtain wall framing: Deflection of framing members in a direction normal to wall plane when subjected to specified design loads shall not exceed L/175 of clear span.
 - b. No glass breakage.
 - 3. Dead load: Deflection of any member in a direction parallel to plane of wall, when carrying its full dead load, shall not exceed an amount which will reduce glass bite below 75% of design dimension and member shall have 1/8" minimum clearance between itself and top of fixed panel, glass, or other fixed part directly below. Clearance between member and an operable door shall be 1/16" minimum.

4. Uniform structural loads and testing requirements: Conduct uniform load structural tests in accord with ASTM E330-02. Subject curtain wall system to inward and outward acting uniform loads equal to 1.5 times inward and outward acting design wind pressure. Satisfactory performance at these loads shall mean no glass breakage, damage to fasteners or anchors, hardware parts or actuating mechanisms; no malfunctioning of windows, doors and operating hardware; no permanent deformation of main framing members in excess of 0.2% of clear span.
- G. Vertical adjustments: Curtain wall system shall allow for vertical adjustment to compensate for irregularities in adjacent surfaces. Adjustment may include shim space at head and sill or interlocking head or sill section. Design shall allow for vertical adjustment without altering glass size and shall not require glass bite reduction below minimum recommended by glass manufacturer. Vertical adjustment provisions shall take into consideration the allowable fabrication and erection tolerances and deflections in adjacent surfaces, and tolerance required by curtain wall construction.
- H. Energy Performance: Glazed aluminum curtain walls shall have certified and labeled energy performance ratings by manufacturer in accordance with NFRC that:
 1. Air leakage shall not exceed 1.0 cfm/ft² for glazed swinging doors.
 2. Air leakage shall not exceed 4.0 cfm/ft² for all other products.
- I. Condensation Resistance (CRF): When tested to AAMA Specification 1503, the condensation resistance factor shall not be less than 73 frame and 68 glass (Low-E).
- J. Sound Transmission Loss: When tested to ASTM E90-04, the Sound Transmission Class (STC) shall not be less than 35 based upon 1" insulating glass (1/2" air space).
- K. Thermal Transmittance (U-factor):
 1. When tested to AAMA Specification 1503, the thermal transmittance (U-factor) shall not be more than: 0.48 (low-E) BTU/hr/ft² /°F. per AAMA 507.
 2. Thermal transmission: Curtain wall system shall be thermally broken by means of non-metallic spacers or gaskets between exposed exterior and interior faces.
- L. Water penetrating curtain wall (punched opening) system shall be contained within the system by gutters and drained to exterior by weep holes. No uncontrolled water infiltration is allowable.
- M. Glazing: Design system for exterior glazing of vision and spandrel areas.
- N. Fasteners: Compatible with material being fastened. Use concealed fasteners in finished work.
- O. Preset anchors: Capable of transmitting design loads and thermal expansion loads assigned to a single anchor with a safety factor of 2.5.

1.3 ACTION SUBMITTALS:

- A. Shop drawings:
 1. Show curtain wall in elevation with sections and details at full scale. Include glass and metal thicknesses, joining details, field connections, anchorage, provisions for expansion, fastening and sealing methods, splice details, metal finishes, and glazing accessories.
 2. Indicate relationships with adjacent and interfacing work.
 3. Indicate supplementary bracing and anchorage required for sloped glazing attached to curtain wall framing system.

- B. Glass manufacturer's approval: Indicate on shop drawings or by letter, prior to submission of shop drawings, that selected glass manufacturers have reviewed and approved details including glass bite, support, clearances, system weepage, air circulation around interior window treatments, shading by exterior building components and glazing methods.
- C. Samples:
 - 1. Visual samples: Submit aluminum finish samples, minimum 6" by 6", of each color and finish specified. Indicate full range of selected color to be expected in curtain wall work.
 - 2. Sealant adhesion test samples: Provide samples of specified metal finish for adhesion tests by sealant manufacturer; as specified in Section 07 9200 - Joint Sealants.
 - 3. Insulated-core metal wall panel with selected finish.

1.4 INFORMATIONAL SUBMITTALS:

- A. Structural design calculations: Submit for Architect's information only. Indicate compliance with specified design criteria. Indicate aluminum alloy and temper and deflection at design wind loads and supplementary loading specified. Design calculations shall bear seal of a professional engineer licensed in the State of Texas. Indicate that engineer has reviewed shop drawings.
- B. Test reports: Submit for Architect's information only:
 - 1. Submit reports by an independent testing laboratory indicating that curtain wall system proposed for use has been tested for compliance with specified design criteria.
 - 2. Tests shall have been made for essentially similar systems having similar glass sizes, mullion lengths, reinforcement and methods of attachment.
 - 3. Tests shall indicate satisfactory testing to at least structural and performance criteria specified.
 - 4. If test data is not available for proposed systems or if data does not represent project conditions, Contractor shall be responsible for securing satisfactory tests by an independent testing agency acceptable to Architect. All costs for such testing shall be borne by the Contractor.
- C. Welder certification: Submit welders' qualifications in accord with AWS D1.1 and AWS D1.2, current within previous 12 months, for Architect's information only.

1.5 CLOSEOUT SUBMITTALS:

- A. Maintenance data: Submit as part of Contract closeout documents. Give instructions for general maintenance and repair of surfaces and finishes. Include detailed re-glazing procedures.
- B. Record drawings: Submit as part of Contract closeout documents. Indicate changes made during construction.

1.6 QUALITY ASSURANCE:

- A. Applicable standards; standards of the following as referenced herein:
 - 1. Aluminum Association (AA).
 - 2. American Architectural Manufacturers Association (AAMA).
 - 3. American Iron and Steel Institute (AISI).
 - 4. American Welding Society (AWS).

5. ASHRAE 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.
 6. ASTM International (ASTM).
 7. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA).
 8. Steel Structures Painting Council (SSPC).
- B. Fabricator and Installer Qualifications: All Work shall be performed by single firm with skilled workmen, specially trained and experienced in this type of Work. Firm must demonstrate minimum five years successful experience in fabrication and installation of Work similar in scope to Work of this Project.
1. Owner and Architect reserve right to visit fabricating facilities of approved Contractor at any time when Work is in progress. All shop and field materials and workmanship are subject to inspection by Architect at all times. Such inspections do not relieve Contractor from obligations to provide Work conforming to all requirements of Documents and as specified herein.
 2. If framing contractor subcontracts any Work, proposed subcontractor's qualifications shall be filed with Architect.
- C. Qualifications of welders:
1. Welders employed on the work shall have passed qualification tests within the past 12 months in the position for which employed, using test procedures covered in the AWS D1.1 and AWS D1.2.
 2. Contractor shall require any welder to re-take the qualification test when, in the opinion of the Architect, the welder's work creates a reasonable doubt as to the proficiency of the welder. Re-tests shall be conducted at no additional expense to the Owner. Re-certification shall be made to the Architect after the welder has passed the test.

1.7 PROJECT/SITE CONDITIONS:

- A. Protection: Protect aluminum surfaces from contact with lime, mortar, cement, acids and other harmful substances as well as from careless handling, storage or machining.

1.8 WARRANTIES:

- A. Endorse and forward to the Owner a five year written warranty covering work performed under this section. Warranty shall cover defective materials, including glazing and caulking materials specified in other sections, workmanship and performance, and shall provide for prompt replacement of damaged materials or repair of leaks at no additional cost to Owner. Warranty shall commence at Date of Substantial Completion.

PART 2 - PRODUCTS

2.1 FRAMING AND DOOR SYSTEMS:

- A. Acceptable manufacturers; subject to compliance with specified requirements:
1. Basis of design; Kawneer North America.
 2. Bruce Engineering Co.
 3. EFCO Corp., a Pella Company.
 4. Oldcastle BuildingEnvelope™.
- B. System 2; Entrance, storefront and punched opening framing system:
1. Basis of design; Kawneer North America, "TriFab VG 451T Front Plane System", extruded aluminum window wall system and punched openings

2. Components and characteristics:
 - a. Member size: 2" by 4-1/2" with perimeter cap and structural glazed verticals.
 - b. System: Two-piece face and gutter, for inside glazing.
 - c. Construction: Shear block or screw spline.
 - d. Glazing gaskets: As specified in Section 08 8000 - Glazing.
 - e. Make provisions in framing for minimum edge clearance, nominal edge cover, and nominal pocket width for thickness and type of glazing material indicated on drawings. Provisions shall be in accord with glazing material manufacturer's product data.
 - f. Trim: Kawneer 'T' shaped profile mullion caps to be custom color to match Alucobond, Beachstone Gray Metallic.
 - g. Thermal break: Kawneer IsoLock® Thermal Break with a nominal 1/4" separation consisting of a two-part chemically curing, high-density polyurethane, which is mechanically and adhesively joined to aluminum storefront (fixed framing) sections.
- C. Entrance doors: Basis of design; Kawneer North America, "500 Heavy Wall Wide Stile" entrance doors.
 1. Medium stile design: Minimum 5" wide stiles and top rail and 12" wide bottom rail and horizontal rail for panic hardware. Horizontal rail must be centered on panic hardware mounting height and be of sufficient width to conceal panic hardware.
 2. Door construction: Fabricated of extruded aluminum sections with door corners joined by concealed reinforcement secured with bolts and screws and by sigma deep penetration welding.
 3. Glazing: Snap-in stops with neoprene glazing gaskets.
 4. Adjustment: Doors equipped with adjusting mechanism located in top rail near lock stile, providing for minor clearance adjustments after installation.
 5. Weatherstripping: Manufacturer's standard pile type in replaceable rabbets for stiles and rails.
 6. Hardware: Refer to Section 08 7100 - Door Hardware.
- D. System 1; Curtain wall framing system: Basis of design: Kawneer North America, "1600 Wall System® 1", extruded aluminum curtain wall system.
 1. Curtain wall and punched openings design:
 - a. Depth: Maximum 7-1/2" inch with perimeter and vertical caps and structurally glazed horizontals.
 - b. Mullion width: 2 1/2-inch front set, outside glazed, captured and structurally glazed, shear block system.
 2. Design: Framing system design shall incorporate the following:
 - a. Framing members exposed to building interior shall be tubular sections or shall incorporate cover trim without joints in individual members.
 - b. Provide system with internal splices at joints.
 - c. Thermal barrier: Kawneer IsoLock® Thermal Break with a nominal 1/4" separation consisting of a two-part chemically curing, high-density polyurethane, which is mechanically and adhesively joined to aluminum storefront (fixed framing) sections.
 3. Curtain wall: Captured verticals and perimeter cap joints and structurally glazed head and sill. Components shall be aluminum extrusions, type and wall thickness to meet specified design criteria. Provide anchors, reinforcement and similar accessories as required to complete installation. System shall be designed for exterior glazing.
 - a. Trim: Kawneer 'T' shaped profile mullion caps to be custom color to match Alucobond, Beachstone Gray Metallic.

4. Thermal barrier: Kawneer IsoLock® Thermal Break with a nominal 1/4" separation consisting of a two-part chemically curing, high-density polyurethane, which is mechanically and adhesively joined to aluminum storefront (fixed framing) sections.

2.2 MATERIALS:

- A. Aluminum components:
 1. Extrusions: Meeting ASTM B221-08; alloy, temper and wall thickness as required to meet design criteria. Structural characteristics of aluminum shall be in accord with AA, "Specification for Aluminum Structures."
 2. Sheet: 5005-H34 alloy meeting ASTM B209-07; minimum 0.125" thickness.
 3. Castings: 356-T6 alloy meeting ASTM B108-08.
- B. Carbon steel:
 1. Carbon steel alloys shall conform to requirements published in American Iron and Steel Products Manual and to ASTM A36-08.
 2. High strength, low alloy steel shall conform to requirements published in American Iron and Steel Products Manual and to ASTM A36-08, ASTM A1008-08a, and ASTM A618-04.
- C. Finish:
 1. Exposed aluminum components and components to which exterior sealant is applied: Two coat, shop-applied, baked-on, fluoropolymer coating system based on minimum 70% Arkema Group, Kynar 500 or Solvay Solexis, Inc., Hylar 5000 resin (Polyvinylidene fluoride, PVDF), formulated by a licensed manufacturer and applied by manufacturer's approved applicator to meet AAMA 2605-05.
 - a. Color: As selected by Architect.
 2. Unexposed aluminum components: Mill finish.

2.3 ACCESSORY PRODUCTS:

- A. Glazing materials, including vision and spandrel glass, glazing gaskets, sealants and accessories: As specified in Section 08 8000 - Glazing.
- B. Perimeter sealant: As specified in Section 07 9200 - Joint Sealants.
- C. Spandrel fire safing: As specified in Section 07 8400 - Firestopping.
- D. Curtain wall (punched opening) sealant:
 1. Non-skinning type meeting AAMA 800; color matching curtain wall.
 2. Provide sealants for use inside of the weatherproofing system that have a VOC content of 250 g/l or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- E. Weep hole filter material: 1/2" square by 6" long, 30-40 ppi open cell, reticulated, polyvinyl chloride coated, polyurethane foam block.
- F. Anchors: AISI Type 302/304 stainless steel; shapes and sizes indicated on approved shop drawings.
- G. Alignment pins: Stainless steel; color matching curtain wall finish.
- H. Structural fasteners: Series 300 stainless steel for all exposed fasteners and fasteners 1/4" diameter and smaller, heavy cadmium-plated steel (0.0005" thickness plating), colored chromate coated for fasteners over 1/4" diameter.
- I. Insulating washers: Fiberglass-reinforced nylon.

- J. Shop primer for steel anchors and connection hardware: Organic, zinc-rich primer meeting SSPC-Paint 20, Type II.
- K. Bituminous coating: Cold-applied, asphalt mastic meeting ASTM D, minimum 30 mil thickness.
- L. Subsills: Extruded aluminum finished to match framing.

2.4 FABRICATION:

- A. Fabricate curtain wall and framing components in accord with approved shop drawings. Shop fabricate to greatest extent practicable to minimize field cutting, splicing and fastening. Remove burrs from cut edges and ease edges and corners to approximately 1/64" radius.
- B. Fabricate system with welded, bolted or screwed connections as indicated on approved shop drawings. Welding shall be in accord with AWS standards, performed by qualified welders. Do not distort members or deface exposed finish. Grind welds smooth.
- C. Steel components:
 - 1. Surface preparation: Clean all surfaces after fabrication and immediately prior to shop painting in accord with SSPC-SP 2, "Hand Tool Cleaning," or SSPC-SP 3, "Power Tool Cleaning," at manufacturer's option.
 - 2. Shop priming:
 - a. Shop prime steel components except surfaces to be field welded.
 - b. Shop prime surfaces after completion of fabrication.
 - c. Apply specified shop primer in accord with manufacturer's product data and SSPC Painting Systems Specifications to provide a minimum dry film thickness of 2.5 mils. Apply shop primer within four hours after cleaning and before rust-bloom occurs. Paint only in relative humidity below 85% and surface temperatures of five °F. above dew point.
- D. Reinforcement: Reinforce aluminum work at anchorage and support points, at joints and attachment points for interfacing work. Provide non-corrosive anchors for fasteners where aluminum is less than 0.125" thickness.

PART 3 - EXECUTION

3.1 PREPARATION:

- A. Pre-glazing conference: Prior to beginning curtain wall erection, a pre-glazing conference shall be held to review work to be accomplished.
 - 1. Contractor, Architect, curtain wall fabrication, erection and glazing subcontractor and other trades with work related to curtain wall installation shall be present.
 - 2. Contractor shall notify applicable parties at least three days prior to time of conference.
 - 3. Contractor shall record minutes of meeting and distribute to all parties in attendance.
- B. Inserts and anchorage:
 - 1. Furnish inserts and anchoring devices which must be preset in concrete on timely basis to avoid delay in the work. Set at locations indicated on approved shop drawings.
 - 2. Coordinate setting drawings, diagrams, templates and instructions for installation of concrete inserts, anchor bolts and miscellaneous items having integral anchors cast in concrete construction.

- C. Shop assembly: Preassemble items in shop to greatest extent possible to minimize field splicing and assembly at project site. Disassemble units only to extent necessary for shipping and handling limitations. Mark units for reassembly and installation.

3.2 INSTALLATION:

- A. Anchors: Verify location and alignment of preset anchors. Report deviations and proposed method for correction to Architect prior to proceeding.
- B. Fastening to in-place construction: Provide anchorage devices and fasteners for securing items to in-place construction, including clip angles and threaded fasteners, anchor bolts and erection bolts of types and sizes indicated on approved shop drawings.
- C. Cutting, fitting and placement: Perform cutting, drilling and fitting for installation of work. Set work in location, alignment and elevation, plumb and level within specified tolerances, true and free of rack; measured from established lines and levels. Install work in accord with approved shop drawings.
- D. Protection: Protect aluminum from contact with dissimilar materials by separating with neoprene gaskets or bituminous coating.
- E. Alignment: Before securing curtain wall components in final position to structure, shim and brace work plumb and level and in designated location.
- F. Completely fill annular space between curtain wall and edge of floor slab with safining insulation to form continuous fire barrier between floors. Install impaling clips for fire safining maximum 24" on center. Seal all joints with approved smoke seal compound.
- G. Expansion control: Locate expansion members as indicated on approved shop drawings. Use alignment pins to maintain position. Make joints only at intersections of framing members.
- H. Sill flashing: Install continuous extruded aluminum subsill and flashing matching finish of curtain wall at conditions where curtain wall rests on floor slab or sill wall. Extend sill flashing continuous, with joints lapped and set in curtain wall sealant, and inside edge turned up to form watertight gutter. Seal penetrations.
- I. Set continuous sill pan members and flashing in full sealant bed as specified in Section 07 9200 - Joint Sealants to produce weathertight installation.
- J. Field connections: Provide welded or bolted connections as indicated on approved shop drawings. Join dissimilar metal by bolting with galvanic separators. Welding shall be performed by qualified welders.
- K. Welded connections: Conduct in accord with AWS standards for type of metal being welded. Clean surfaces to be welded as specified in shop cleaning. Weld no finished, exposed members. Perform no welding at locations where discoloration or other damage would result on exposed surfaces.
- L. Bolted connections: Provide slotted holes to allow for alignment of members.
- M. Weep holes: Install weep hole baffle with filter at weep holes. Install filter under 30% compression. Verify during installation that curtain wall system allows water which enters the system to be collected in gutters and weeped to exterior. Ascertain that weep holes are open and that metal-to-metal joints are sealed.

- N. Caulking:
 - 1. Caulk metal-to-metal internal curtain wall joints using curtain wall sealant. Install in accord with Section 07 9200 - Joint Sealants.
 - 2. Caulk perimeter of curtain wall using sealant as specified in Section 07 9200 - Joint Sealants. Caulk both exterior and interior faces of curtain wall perimeter.
- O. Site tolerances:
 - 1. Maximum variation from plumb, level or designated position: 1/8" in 10'-0" vertical or 1/8" in 20'-0" horizontal; not exceeding 1/4" in 40'-0" any direction.
 - 2. Maximum offset in alignment between two consecutive members in line, end to end: 1/16".
 - 3. Maximum offset between framing members at corners of glazing pocket: 1/32".

3.3 CLEANING:

- A. Cleaning: Maintain curtain wall assembly in clean condition during construction period. Immediately remove stains or materials having adverse effect on curtain wall materials and finishes. Remove excess glazing and sealant compounds.
- B. Final cleaning: Just prior to Date of Substantial Completion, clean entire curtain wall assembly, including interior and exterior metal. Clean using pre-tested detergent and water. Flush with clean water. Repair or replace work which cannot be cleaned or which has been damaged during construction operations.

3.4 FIELD QUALITY CONTROL:

- A. Field tests: Conduct to ascertain that curtain wall system is watertight.
 - 1. Conduct in accord with AAMA 501.2, at locations selected by Architect.
 - 2. Perform a minimum of two tests.
 - 3. Perform tests in Architect's presence.
 - 4. Test to be performed by a professional accredited by AAMA to perform the test.

END OF SECTION

SECTION 08 7100 - DOOR HARDWARE

PART 1 GENERAL

2.01 SECTION INCLUDES

- A. Hardware for wood, aluminum, hollow metal doors.
- B. Hardware for fire-rated doors.
- C. Electrically operated and controlled hardware.
- D. Lock cylinders for doors with balance of hardware specified in other sections.
- E. Thresholds.
- F. Smoke and draft control seals.
- G. Weatherstripping and gasketing.

2.02 RELATED REQUIREMENTS

- A. Section 080671 - Door Hardware Schedule: Schedule of door hardware sets.
- B. Section 081113 - Hollow Metal Doors and Frames.
- C. Section 081213 - Hollow Metal Frames.
- D. Section 081416 - Flush Wood Doors.
- E. Section 081433 - Stile and Rail Wood Doors.
- F. Section 084313 - Aluminum-Framed Storefronts: Door hardware, except as noted in section.
- G. Section 102600 - Wall and Door Protection: Door and frame protection.
- H. Section 281000 - Access Control: Electronic access control devices.

2.03 REFERENCE STANDARDS

- A. ADA Standards - Americans with Disabilities Act (ADA) Standards for Accessible Design 2010.
- B. ASTM E283/E283M - Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Skylights, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen 2019.
- C. BHMA A156.1 - Standard for Butts and Hinges 2021.
- D. BHMA A156.2 - Bored and Preassembled Locks and Latches 2017.
- E. BHMA A156.3 - Exit Devices 2020.
- F. BHMA A156.4 - Door Controls - Closers 2019.
- G. BHMA A156.5 - Cylinders and Input Devices for Locks 2020.
- H. BHMA A156.6 - Standard for Architectural Door Trim 2021.
- I. BHMA A156.7 - Template Hinge Dimensions 2016.
- J. BHMA A156.8 - Door Controls - Overhead Stops and Holders 2021.
- K. BHMA A156.16 - Auxiliary Hardware 2018.
- L. BHMA A156.18 - Materials and Finishes 2020.
- M. BHMA A156.21 - Thresholds 2019.
- N. BHMA A156.22 - Standard for Gasketing 2021.
- O. BHMA A156.28 - Recommended Practices For Mechanical Keying Systems 2018.

- P. BHMA A156.31 - Electric Strikes and Frame Mounted Actuators 2019.
- Q. BHMA A156.115 - Hardware Preparation In Steel Doors And Steel Frames 2016.
- R. BHMA A156.115W - Hardware Preparation in Wood Doors with Wood or Steel Frames 2006.
- S. DHI (H&S) - Sequence and Format for the Hardware Schedule 2019.
- T. DHI (KSN) - Keying Systems and Nomenclature 2019.
- U. DHI (LOCS) - Recommended Locations for Architectural Hardware for Standard Steel Doors and Frames 2004.
- V. DHI WDHS.3 - Recommended Locations for Architectural Hardware for Flush Wood Doors 1993; also, in WDHS-1/WDHS-5 Series, 1996.
- W. ICC A117.1 - Accessible and Usable Buildings and Facilities 2017.
- X. ITS (DIR) - Directory of Listed Products current edition.
- Y. MIL-STD-810 - Environmental Engineering Considerations and Laboratory Tests 2019h.
- Z. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- AA. NFPA 80 - Standard for Fire Doors and Other Opening Protectives 2022.
- BB. NFPA 105 - Standard for Smoke Door Assemblies and Other Opening Protectives 2022.
- CC. NFPA 252 - Standard Methods of Fire Tests of Door Assemblies 2022.
- DD. UL (DIR) - Online Certifications Directory Current Edition.
- EE. UL 10C - Standard for Positive Pressure Fire Tests of Door Assemblies Current Edition, Including All Revisions.
- FF. UL 294 - Access Control System Units Current Edition, Including All Revisions.
- GG. UL 1034 - Standard for Safety Burglary-Resistant Electrical Locking Mechanisms 2015.
- HH. UL 1784 - Standard for Air Leakage Tests of Door Assemblies Current Edition, Including All Revisions.

2.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordinate the manufacture, fabrication, and installation of products that door hardware is installed on.
- B. Sequence installation to ensure facility services connections are achieved in an orderly and expeditious manner.
- C. Preinstallation Meeting: Convene a preinstallation meeting one week prior to commencing work of this section; require attendance by affected installers and the following:
 - 1. Architect.
 - 2. Suppliers Architectural Hardware Consultant (AHC).
 - 3. Hardware Installer.
 - 4. Owner's Security Consultant.
- D. Furnish templates for door and frame preparation to manufacturers and fabricators of products requiring internal reinforcement for door hardware.
- E. Keying Requirements Meeting:
 - 1. Supplier will schedule meeting prior to Contractor occupancy.
 - 2. Attendance Required:
 - a. Owner.
 - b. Best Keying Specialist.
 - 3. Agenda:
 - a. Establish keying requirements.
 - b. Verify locksets and locking hardware are functionally correct for project requirements.

- c. Verify that keying and programming complies with project requirements.
- d. Establish keying submittal schedule and update requirements.
4. Incorporate "Keying Requirements Meeting" decisions into keying submittal upon review of door hardware keying system including, but not limited to, the following:
5. Record minutes and distribute copies within two days after meeting to participants, with two copies to Architect, Owner, participants, and those affected by decisions made.
6. Deliver established keying requirements to manufacturers.

2.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Manufacturer's catalog literature for each type of hardware, marked to clearly show products to be furnished for this project, and includes construction details, material descriptions, finishes, and dimensions and profiles of individual components.
- C. Shop Drawings - Door Hardware Schedule: A detailed listing that includes each item of hardware to be installed on each door.
 1. Prepared by or under supervision of Architectural Hardware Consultant (AHC).
 2. Comply with DHI (H&S) using door numbering scheme and hardware set numbers as indicated in Contract Documents.
 - a. Submit in vertical format.
 3. Include complete description for each door listed.
 4. Include manufacturers and product names, and catalog numbers; include functions, types, styles, sizes and finishes of each item.
 5. Include account of abbreviations and symbols used in schedule.
- D. Shop Drawings - Electrified Door Hardware: Include diagrams for power, signal, and control wiring for electrified door hardware that include details of interface with building safety and security systems. Provide elevations and diagrams for each electrified door opening as follows:
 1. Prepared by or under supervision of Architectural Hardware Consultant (AHC) and Electrified Hardware Consultant (EHC).
 2. Elevations: Include front and back elevations of each door opening showing electrified devices with connections installed and an operations narrative describing how opening operates from either side at any given time.
 3. Diagrams: Include point-to-point wiring diagrams that show each device in door opening system with related colored wire connections to each device.
- E. Manufacturer's Installation Instructions: Indicate special procedures and perimeter conditions requiring special attention.
- F. Manufacturer's qualification statement.
- G. Installer's qualification statement.
- H. Supplier's qualification statement.
- I. Maintenance Data: Include data on operating hardware, lubrication requirements, and inspection procedures related to preventative maintenance.
- J. Keying Schedule:
 1. Submit three (3) copies of Keying Schedule in compliance with requirements established during Keying Requirements Meeting unless otherwise indicated.
- K. Warranty: Submit manufacturer's warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.
- L. Project Record Documents: Record actual locations of concealed equipment, services, and conduit.
- M. Maintenance Materials and Tools: Furnish the following for Owner's use in maintenance of project.

1. See Section 016000 - Product Requirements, for additional provisions.

2.06 QUALITY ASSURANCE

- A. Standards for Fire-Rated Doors: Maintain one copy of each referenced standard on site, for use by Architect and Contractor.
- B. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section with minimum three years of documented experience.
- C. Installer Qualifications: Company specializing in performing work of the type specified for commercial door hardware with at least three years of documented experience.
- D. Supplier Qualifications: Company with certified Architectural Hardware Consultant (AHC) and Electrified Hardware Consultant (EHC) to assist in work of this section.

2.07 DELIVERY, STORAGE, AND HANDLING

- A. Package hardware items individually; label and identify each package with door opening code to match door hardware schedule.

2.08 WARRANTY

- A. See Section 017800 - Closeout Submittals for additional warranty requirements.
- B. Manufacturer Warranty: Provide manufacturer warranty against defects in material and workmanship for period indicated, from Date of Substantial Completion. Complete forms in Owner's name and register with manufacturer.
 1. Closers: Thirty Years minimum.
 2. Exit Devices: Three years, minimum.
 3. Locksets and Cylinders: Ten years, minimum.
 4. Other Hardware: Two years, minimum.

PART 2 PRODUCTS

3.01 GENERAL REQUIREMENTS

- A. Provide specified door hardware as required to make doors fully functional, compliant with applicable codes, and secure to extent indicated.
- B. Provide individual items of single type, of same model, and by same manufacturer.
- C. Locks: Provide a lock for each door, unless it's indicated that lock is not required.
 1. Lock Function: Provide lock and latch function numbers and descriptions of manufacturer's Series. As indicated in hardware sets.
 - a. Provide an office lockset for swinging doors for which a lock function is not indicated.
 2. Trim: Provide lever handle or pull trim on outside of each lock, unless otherwise indicated.
 3. Strikes:
 - a. Finish: To match lock or latch.
 - b. Curved-Lip Strikes: Provide as standard, with extended lip to protect frame, unless otherwise indicated.
 - c. Center Strike At Pairs of Doors: 7/8 inch (22.2 mm) lip.
- D. Door Pulls and Push Plates:
 1. Provide door pulls and push plates on doors without a lockset, latchset, exit device, or auxiliary lock unless otherwise indicated.
 2. On solid doors, provide matching door pull and push plate on opposite faces.
- E. Closers:
 1. Provide door closer on each exterior door, unless otherwise indicated.
 2. Provide door closer on each fire-rated and smoke-rated door.
 3. Spring hinges are not an acceptable self-closing device, unless otherwise indicated.
- F. Overhead Stops and Holders (Door Checks).

1. Provide stop for every swinging door, unless otherwise indicated.
 2. Overhead Stop is not required if positive stop feature is specified for door closer; positive stop feature of door closer is not an acceptable substitute for a stop, unless otherwise indicated.
 3. Overhead stop is not required if a floor or wall stop has been specified for the door.
- G. Thresholds:
1. Exterior Applications: Provide at each exterior door, unless otherwise indicated.
- H. Smoke and Draft Control Seals:
1. Provide gasketing for smoke and draft control doors that complies with local codes, requirements of assemblies tested in accordance with UL 1784.
- I. Weatherstripping and Gasketing:
1. Provide weatherstripping on each exterior door at head, jambs, and meeting stiles of door pairs, unless otherwise indicated.
 2. Provide door bottom sweep on each exterior door, unless otherwise indicated.
 3. Provide applicable gasketing on doors indicated as indicated in the hardware schedule.
 4. Fabricate as continuous gasketing, do not cut or notch gasketing material.
- J. Electrically Operated and/or Controlled Hardware: Provide necessary power supplies, power transfer hinges, relays, and interfaces as required for proper operation; provide wiring between hardware and control components and to building power connection in compliance with NFPA 70.
- K. See Section 281000 for additional access control system requirements.
- L. Fasteners:
1. Provide fasteners of proper type, size, quantity, and finish that comply with commercially recognized standards for proposed applications.
 - a. Aluminum fasteners are not permitted.
 - b. Provide phillips flat-head screws with heads finished to match door surface hardware unless otherwise indicated.
 2. Provide machine screws for attachment to reinforced hollow metal and aluminum frames.
 - a. Self-drilling (Tek) type screws are not permitted.
 3. Provide stainless steel machine screws and lead expansion shields for concrete and masonry substrates.
 4. Provide wall grip inserts for hollow wall construction.
 5. Fire-Resistance-Rated Applications: Comply with NFPA 80.
 - a. Provide wood or machine screws for hinges mortised to doors or frames, strike plates to frames, and closers to doors and frames.
 - b. Provide steel through bolts for attachment of surface mounted closers, hinges, or exit devices to door panels unless proper door blocking is provided.

3.02 PERFORMANCE REQUIREMENTS

- A. Provide door hardware products that comply with the following requirements:
1. Applicable provisions of federal, state, and local codes.
 2. Accessibility: ADA Standards and ICC A117.1.
 3. Fire-Resistance-Rated Doors: NFPA 80, listed and labeled by qualified testing agency for fire protection ratings indicated, based on testing at positive pressure in accordance with NFPA 252 or UL 10C.
 4. Hardware on Fire-Resistance-Rated Doors: Listed and classified by or as suitable for application indicated.
 5. Hardware for Smoke and Draft Control Doors: Provide door hardware that complies with local codes, and requirements of assemblies tested in accordance with UL 1784.
 6. Hardware Preparation for Steel Doors and Steel Frames: BHMA A156.115.
 7. Hardware Preparation for Wood Doors with Wood or Steel Frames: BHMA A156.115W.

8. Products Requiring Electrical Connection: Listed and classified by UL (DIR) as suitable for the purpose specified.

3.03 HINGES

- A. Manufacturers: Conventional butt hinges.
 1. BEST; dormakaba Group: www.bestaccess.com/#sle.
 2. Substitutions: See Section 016000 - Product Requirements.
- B. Properties:
 1. Butt Hinges: As applicable to each item specified.
 - a. Standard Weight Hinges: Minimum of two (2) permanently lubricated non-detachable bearings.
 - b. Heavy Weight Hinges: Minimum of four (4) permanently lubricated bearings on heavy weight hinges.
 - c. Template screw hole locations.
 - d. Bearing assembly installed after plating.
 - e. Bearings: Exposed fully hardened bearings.
 - f. Bearing Shells: Shapes consistent with barrels.
 - g. Pins: Easily seated, non-rising pins.
 - 1) Fully plate hinge pins.
 - 2) Non-Removable Pins: Slotted stainless steel screws.
 - h. UL 10C listed for fire-resistance-rated doors.
 - i. Electrified Hardware Functions: Use hinges similar to conventional hinges used at the door leaf and designed to facilitate power transfer.
 - 1) Wiring: Concealed PTFE-jacketed wires, secured at each leaf and continuous through hinge knuckle. Provide wire quantity and sizes required for electric hardware be served and length sufficient for connection from locking hardware to power supply or junction box.
 - 2) Connectors: Use Molex type.
- C. Sizes: See Door Hardware Schedule.
 1. Hinge Widths: As required to clear surrounding trim.
 2. Sufficient size to allow 180 degree swing of door.
- D. Finishes: See Door Hardware Schedule.
 1. Fully polish hinges, front, back, and barrel.
- E. Grades:
 1. Butt Hinges: Comply with BHMA A156.1 and BHMA A156.7 for templated hinges.
 2. Comply with BHMA A156.18 Materials and Finishes.
- F. Material: Base metal as indicated for each item by BHMA material and finish designation.
- G. Types:
 1. Butt Hinges: Include full mortise hinges.
- H. Options: As applicable to each item specified.
 1. Provide electric power transfer (EPT) as listed in hardware sets.
 2. Provide concealed electric (CE) as listed in the hardware sets.
- I. Quantities:
 1. Butt Hinges: Three (3) hinges per leaves up to 90 inches (2286 mm) in height. Add one (1) for each additional 30 inches (762 mm) in height or fraction thereof.
 - a. Hinge weight and size unless otherwise indicated in hardware sets:
 - 1) For doors up to 36 inches (914 mm) wide and up to 1-3/4 inches (44.5 mm) thick provide hinges with a minimum thickness of 0.134 inch (3.4 mm) and a minimum of 4-1/2 inches (114 mm) in height.

- 2) For doors from 36 inches (914 mm) wide up to 42 inches (1067 mm) wide and up to 1-3/4 inches (44.5 mm) thick provide hinges with a minimum thickness of 0.145 inch (3.7 mm) and a minimum of 4-1/2 inches (114 mm) in height.
 - 3) For doors from 42 inches (1067 mm) wide up to 48 inches (1219 mm) wide and up to 1-3/4 inches (44.5 mm) thick provide hinges with a minimum thickness of 0.180 inch (4.6 mm) and a minimum of 5 inches (127 mm) in height.
 - 4) For doors greater than 1-3/4 inches (44.5 mm) thick provide hinges with a minimum thickness of 0.180 inch (4.6 mm) and a minimum of 5 inches (127 mm) in height.
- J. Applications: At swinging doors.
1. Provide non-removable pins at out-swinging doors with locking hardware and all exterior doors.
- K. Products:
1. Butt Hinges:
 - a. Ball Bearing, Five (5) Knuckle.

3.04 BOLTS

- A. Manufacturers:
1. Trimco: www.trimcohardware.com/#sle.
 2. Substitutions: See Section 016000 - Product Requirements.
- B. Properties:
1. Flush Bolts:
 - a. Pairs of Swing Doors: At inactive leaves, provide flush bolts of type as required to comply with code.
 - b. Automatic Flush Bolts: Automatically latching upon closing of door leaf.
 - 1) Bolt Throw: 3/4 inch (19 mm), minimum.
 2. Dustproof Strikes: For bolting into floor, provide except at metal thresholds.
- C. Options:
1. Lever extensions: Provide for top bolt at oversized doors.
- D. Products:
1. Automatic flush bolts.

3.05 EXIT DEVICES

- A. Manufacturers:
1. BEST, dormakaba Group: www.bestaccess.com/#sle.
 2. Substitutions: Not permitted.
- B. Properties:
1. Actuation: Full-length touchpad.
 2. Chassis:
 - a. Construction: Investment cast steel, zinc dichromate plated.
 - b. Compatibility: Standard Stile and Narrow Stile doors.
 3. Touchpads: "T" style metal touchpads and rail assemblies with matching chassis covers end caps.
 4. Latch Bolts: Stainless steel deadlocking with 3/4 inch (19 mm) projection using latch bolt.
 5. Lever Design: Match project standard lockset trims.
 6. Cylinder: Include where cylinder dogging or locking trim is indicated.
 7. Strike as recommended by manufacturer for application indicated.
 8. Sound dampening on touch bar.
 9. Dogging:
 - a. Non-Fire-Resistance-Rated Devices: Cylinder 1/4 inch (6 mm) hex key dogging.
 - b. Fire-Resistance-Rated Devices: Manual dogging not permitted.

10. Touch bar assembly on wide style exit devices to have a 1/4 inch (6.3 mm) clearance to allow for vision frames.
 11. All exposed exit device components to be of architectural metals and "true" architectural finishes.
 12. Handing: Field-reversible.
 13. Fasteners on Back Side of Device Channel: Concealed - exposed fasteners not allowed.
 14. Vertical Latch Assemblies' Operation: Gravity, without use of springs.
- C. Grades: Complying with BHMA A156.3, Grade 1.
1. Provide exit devices tested and certified by UL or by a recognized independent laboratory for mechanical operational testing to 10 million cycles minimum with inspection confirming Grade 1 Loaded Forces have been maintained.
- D. Code Compliance: As required by authorities having jurisdiction in the State in which the Project is located.
- E. Options:
1. Electrified Devices:
 - a. Latchbolt Retraction: motorized latchbolt retraction.
 2. Internally mounted switch used to signal other components.
 3. Internally mounted switch that monitors the position of the latchbolt.
 4. MLR: Motorized latch retraction.
 5. Electrified Device Voltage: 24 VAC.
 6. Provide units meeting requirements of MIL-STD-810F, Method 506.4, Driving Rain Test and Method 509.4, Salt Fog Test.
 - a. Provide an internally mounted switch that is to be used to signal other components.
- F. Products:
1. 2000.

3.06 ELECTRIC STRIKES

- A. Manufacturers:
1. RCI; dormakaba Group: www.dormakaba.com/us-en/#sle.
 2. Substitutions: Not permitted.
- B. Properties:
1. Provide UL (DIR) listed burglary-resistant devices.
 2. Provide UL 1034 compliant devices.
 3. Provide UL 10C compliant devices.
 4. Non-handed devices suitable for door frame material and scheduled lock configuration.
 5. Include transformer and rectifier as necessary for complete installation.
 6. Holding Force: 1,500 lbs (680.4 kg).
 7. Accommodating latch projections of 1/2 inch (13 mm) or 5/8 inch (16 mm).
- C. Grades: Complying with BHMA A156.31, Grade 1.
- D. Options: As applicable to each item specified.
1. Voltage: 24 VDC.
 2. Provide adjustable dead bolt keeper and deadlatch ramp.
- E. Installation: Connect electric strikes into fire alarm where non-rated doors are scheduled to release with fire or sprinkler alarm condition.
- F. Products:
1. 2 Series (F2164, 2366).

3.07 LOCK CYLINDERS

- A. Manufacturers:
1. BEST, dormakaba Group: www.bestaccess.com/#sle.

- B. Properties:
 - 1. Lock Cylinders: Provide key access on outside of each lock, unless otherwise indicated.
 - a. Provide cylinders from same manufacturer as locking device.
 - b. Provide cams and/or tailpieces as required for locking devices.
 - c. Provide cylinders with appropriate format interchangeable cores where indicated.
- C. Grades:
 - 1. Standard Security Cylinders: Comply with BHMA A156.5.
- D. Material:
- E. Types: As applicable to each item specified.
 - 1. Standard security small format interchangeable core (SFIC) type cylinders, with six-pin, 6C cores.
- F. Applications: At locations indicated in hardware sets, and as follows
 - 1. As required for items with locking devices provided by other sections, including at elevator controls and cabinets.
 - a. When provisions for lock cylinders are referenced elsewhere in the Project Manual to this Section, provide compatible type of lock cylinder, keyed to building keying system, unless otherwise indicated.
- G. Products:
 - 1. Rim/mortise.

3.08 CYLINDRICAL LOCKS

- A. Manufacturers:
 - 1. BEST, dormakaba Group: www.bestaccess.com/#sle.
 - 2. Substitutions: Not permitted.
- B. Properties:
 - 1. UL listed for use on single or pairs of doors with fire-resistance-rating up to 3 hours and latchbolt throw of 1/2 inch (12.7 mm).
 - 2. Mechanical Locks:
 - a. Fitting modified ANSI A115.2 door preparation.
 - b. Door Thickness Fit: 1-3/8 inches (35 mm) to 2-1/4 inches (57 mm) thick doors.
 - c. Construction: Hub, side plate, shrouded rose, locking pin to be a one-piece casting with a shrouded locking lug.
 - 1) Through-bolted anti-rotational studs.
 - d. Cast stainless steel latch retractor with roller bearings for exceptionally smooth operation and superior strength and durability.
 - e. Bored Hole: 2-1/8 inch (54 mm) diameter.
 - f. Backset: 2-3/4 inches (70 mm) unless otherwise indicated.
 - g. Latch: Single piece tail-piece construction.
 - 1) Latchbolt Throw: 9/16 inch (14.3 mm), minimum.
 - h. Cylinders:
 - 1) Cylinder Core Types: Locks capable of supporting manufacturers' cores, as applicable.
 - (a) Small format interchangeable.
 - i. Lever Trim:
 - 1) Style: See Door Hardware Schedule.
 - 2) Functionality: Allow the lever handle to move up to 45 degrees from horizontal position prior to engaging the latchbolt assembly.
 - 3) Strength: Locksets outside locked lever designed to withstand minimum 1,400 inch-lbs (158.2 Nm) of torque. In excess of that, a replaceable part will shear. Key from outside and/or inside lever will still operate lockset.
 - 4) Independent spring mechanism for each lever.

- (a) Contain lever springs in the main lock hub.
 - 5) Outside Lever Sleeve: Seamless one-piece construction.
 - 6) Keyed Levers: Removable only after core is removed by authorized control key.
- 3. Electrified Locks: Same properties as standard locks, and as follows:
 - a. Voltage: 24 VDC.
 - b. Function: Electrically locked (Fail Safe) or unlocked (Fail Secure), as indicated for each lock in Door Hardware Schedule.
 - c. Temperature Control Module (TCM).
- C. Finishes: See Door Hardware Schedule.
 - 1. Core Faces: Match finish of lockset.
- D. Grades: Comply with BHMA A156.2, Grade 1, Series 4000, Operational Grade 1, Extra Heavy Duty.
 - 1. Durability: Passing 50 Million cycle tests verified by third party testing agency.
- E. Material: Manufacturer's standard for specified lock.
 - 1. Critical Latch and Chassis Components: Brass or corrosion-resistance treated steel.
 - 2. Outside Lever Sleeve: Hardened steel alloy.
- F. Options:
- G. Products: Cylindrical locks, including mechanical and electrified types.
 - 1. 9K (Grade 1).

3.09 DOOR PULLS AND PUSH PLATES

- A. Manufacturers:
 - 1. Trimco: www.trimcohardware.com/#sle.
 - 2. Substitutions: See Section 016000 - Product Requirements.
- B. Properties:
 - 1. Pull Type: Straight, unless otherwise indicated.
 - 2. Push Plate Type: Flat, with square corners, unless otherwise indicated.
 - a. Edges: Beveled, unless otherwise indicated.
- C. Grades: Comply with BHMA A156.6.
- D. Material: Stainless steel, unless otherwise indicated.
- E. Products:
 - 1. Push-Pull Plates.
 - 2. 1000 Series.

3.10 COORDINATORS

- A. Manufacturers:
 - 1. Trimco: www.trimcohardware.com/#sle.
 - 2. Substitutions: See Section 016000 - Product Requirements.
- B. Properties:
 - 1. General: Non-handed devices, with field-selectable active door leaf.
 - 2. Coordinators: Devices on pairs of doors with closers and self-latching or automatic flush bolts installed.
 - a. Coordinator Operation: Only when inactive door is opened.
- C. Grades:
- D. Code Compliance: As required by authorities having jurisdiction in the State in which the Project is located.
 - 1. Meet UL 10C for Positive Pressure.
- E. Types:
 - 1. Coordinators: Bar.

- F. Installation:
 - 1. Mounting: Provide necessary mounting brackets and filler bars to ensure proper installation of coordinator and related hardware.
 - 2. Coordination: Properly sequence installation of other door hardware affected by placement of coordinators and carry bars.
- G. Products:
 - 1. 3090 Series.

3.11 CARRY BARS

- A. Manufacturers:
 - 1. Trimco: www.trimcohardware.com/#sle.
 - 2. Substitutions: See Section 016000 - Product Requirements.
- B. Material: Brass with nylon rollers, unless otherwise indicated.
- C. Products:
 - 1. 3090 Carry Open Bar Assembly.

3.12 CLOSERS

- A. Manufacturers:
 - 1. BEST, dormakaba Group www.bestaccess.com/#sle.
 - 2. Substitutions: Not permitted.
- B. Properties:
 - 1. Surface Mounted Closers: Manufacturer's standard.
 - a. Construction: R14 high silicon aluminum alloy.
 - b. Maximum Projection from Face of Door: 2-1/8 inches (54 mm).
 - c. Mechanism: Separate tamper-resistant adjusting valves for closing and latching speeds.
 - 1) Include advanced backcheck feature.
 - 2) Include delayed action feature.
 - d. Hydraulic Fluid: All-weather type.
 - e. Arm Assembly: Standard for product specified.
 - 1) Include hold-open, integral stop, or spring-loaded stop feature, as specified in Door Hardware Schedule.
 - 2) Parallel arm to be a heavy-duty rigid arm.
 - 3) Where "IS" or "S-IS" arms are specified in hardware sets, if manufacturer does not offer this arm provide a regular arm mount closer in conjunction with a heavy-duty overhead stop equal to a dormakaba 900 Series.
 - f. Covers:
 - 1) Type: Standard for product selected.
 - (a) Full.
 - 2) Material: Plastic.
 - 3) Finish: Painted.
- C. Grades:
 - 1. Closers: Comply with BHMA A156.4, Grade 1.
 - a. Underwriters Laboratories Compliance:
 - 1) Product Listing: UL (DIR) and ULC for use on fire-resistance-rated doors.
 - (a) UL 228 - Door Closers-Holders, With or Without Integral Smoke Detectors.
- D. Types:
 - 1. Rack-and-pinion, surface-mounted. 1-1/2 inches (38 mm) minimum bore.
- E. Options:
 - 1. Cushion limit stay.

- F. Installation:
 - 1. Mounting: Includes surface mounted installations.
 - 2. Mount closers on non-public side of door and stair side of stair doors unless otherwise noted in hardware sets.
 - 3. At outswinging exterior doors, mount closer on interior side of door.
 - 4. Provide adapter plates, shim spacers, and blade stop spacers as required by frame and door conditions.
 - 5. Where an overlapping astragal is included on pairs of swinging doors, provide coordinator to ensure door leaves close in proper order.
- G. Products:
 - 1. Surface Mounted:
 - a. HD7000.

3.13 OVERHEAD STOPS AND HOLDERS

- A. Manufacturers:
 - 1. Architectural Builders Hardware Mfg (ABH): www.abhmfg.com/#sle.
 - 2. Substitutions: See Section 016000 - Product Requirements.
- B. Properties:
 - 1. Stop Settings: At 85 degrees opening.
 - a. Adjustable friction tension.
- C. Sizes: Manufacturer's standard for the application.
- D. Finishes:
 - 1. Arms and Brackets: Zinc-plated.
- E. Grades: As applicable to item specified.
 - 1. Comply with BHMA A156.8, Grade 1.
- F. Material: Base metal as indicated for each item by BHMA material and finish designation.
 - 1. Track Channel: Extruded aluminum alloy.
 - 2. Slide Block: Machined from solid brass alloy.
- G. Types:
 - 1. Surface-applied.
- H. Products:
 - 1. Surface Overhead Stops and Holders:
 - a. ABH 4420 Series.

3.14 PROTECTION PLATES

- A. Manufacturers:
 - 1. Trimco: www.trimcohardware.com/#sle.
 - 2. Substitutions: See Section 016000 - Product Requirements.
- B. Properties:
 - 1. Plates:
 - a. Kick Plates: Provide along bottom edge of push side of every wood door with closer, except aluminum storefront and glass entry doors, unless otherwise indicated.
 - b. Edges: Beveled, on four (4) unless otherwise indicated.
- C. Grades: Comply with BHMA A156.6.
- D. Material: As indicated for each item by BHMA material and finish designation.
 - 1. Metal Properties: Stainless steel.
- E. Installation:
 - 1. Fasteners: Countersunk screw fasteners
- F. Products:

1. K0050 Series.

3.15 STOPS AND HOLDERS

- A. Manufacturers:
 1. Trimco: www.trimcohardware.com/#sle.
 2. Substitutions: See Section 016000 - Product Requirements.
- B. General: Provide overhead stop/holder when wall or floor stop is not feasible.
- C. Properties:
 1. Wall Bumpers: 1270CVSV.
- D. Grades:
 1. Door Holders, Wall Bumpers, and Floor Stops: Comply with BHMA A156.16 and Resilient Material Retention Test as described in this standard.
- E. Material: Base metal as indicated for each item by BHMA material and finish designation.
- F. Types:
 1. Wall Bumpers: Bumper, concave, wall stop.
 2. Floor Stops: Provide with bumper floor stop.
- G. Installation:
 1. Non-Masonry Walls: Confirm adequate wall reinforcement has been installed to allow lasting installation of wall bumpers.
- H. Products:
 1. Wall Bumpers.
 2. Floor Stops.

3.16 THRESHOLDS

- A. Manufacturers:
 1. National Guard Products, Inc: www.ngpinc.com/#sle.
 2. Substitutions: See Section 016000 - Product Requirements.
- B. Properties:
 1. Threshold Surface: Fluted horizontal grooves across full width.
- C. Grades: Thresholds: Comply with BHMA A156.21.
- D. Types: As applicable to project conditions. Provide barrier-free type at every location where specified.
 1. Saddle Thresholds: Without thermal break.
- E. Products:

3.17 WEATHERSTRIPPING AND GASKETING

- A. Manufacturers:
 1. National Guard Products, Inc: www.ngpinc.com/#sle.
 2. Substitutions: See Section 016000 - Product Requirements.
- B. Properties:
 1. Adhesive-Backed Perimeter Gasketing: Silicone gasket material applied to frame with self- adhesive.
 2. Rigid, Housed, Perimeter Gasketing: Sponge silicone gasket material held in place by aluminum housing; fastened to frame stop with screws.
 3. Door Sweeps: Neoprene gasket material held in place by flat aluminum housing or flange; surface mounted to face of door with screws.
- C. Grades: Comply with BHMA A156.22.
- D. Products:
 1. Weatherstripping: See Door Hardware Schedule.

2. Smoke Seals: See Door Hardware Schedule.
3. Door Bottom Seals:
 - a. Door Sweeps: See Door Hardware Schedule.

3.18 ELECTRIFIED HARDWARE

- A. Manufacturers:
 1. BEST, dormakaba Group: www.bestaccess.com/#sle.
 2. dormakaba; dormakaba Group: www.dormakaba.com/us-en/#sle.
 3. RCI; dormakaba Group: www.dormakaba.com/us-en/#sle.
 4. Substitutions: Not permitted.
- B. Properties:
 1. Power Supply Units: Manufacturer's standard.
 - a. Regulatory Compliance:
 - 1) United States Compliance:
 - (a) UL listed for Class II Output.
 - (b) Comply with UL 294 Standards incorporating enhanced Access Control. communications capabilities.
 - 2) Canada Compliance:
 - (a) Comply with ULC S-319 Electronic Access Control Systems.
 - b. Enclosures: Lockable NEMA Type 1, with hinged cover and knockouts.
 - c. Power: 24 VAC, 10 Amp; field-selectable.
 - 1) Incoming Power Voltage: 120 VAC.
 - 2) Input circuit protection fuse.
 - 3) Output circuit protection with 3 Amp push-to-reset breaker.
 - 4) Output circuit protection with 4 Amp fuse.
 - d. Emergency Release Terminals: Designed to release devices upon activation of fire alarm system.
 - e. Auxiliary contacts for remote signaling.
 - f. User-selectable time delay from 0 to 4 minutes.
 - g. Fire Alarm System Interface: Standard.
 - 1) Fire alarm terminal with green LED indicating power is available.
 - h. Output Distribution Board with indicator LEDs.
 - i. On/Off LED power indicator.
 2. Power Transfers: Manufacturer's standard.
 - a. Door Loops:
 - 1) Armored flex conduits 18 inches (450 mm) long.
 - 2) Capacity: Up to 1/4 inch (6.35 mm) diameter wire bundle.
 - b. Mortised Type:
 - 1) Stainless steel housing and flexible tube.
 - 2) Accommodate 120 degree door swing.
 3. Wire Harnesses: Of sufficient length, with quick connectors.
 - a. Wire Harness End Connection to Power Supply or Junction Box: One end with bare leads.
- C. Products:
 1. Power Supplies:
 - a. RPSMLR2.
 - b. DKPS Series.
 2. Power Transfers:
 - a. EPT-12C.

3.19 KEYS AND CORES

- A. Manufacturers:

1. BEST, dormakaba Group: www.bestaccess.com/#sle.
2. Substitutions: Not permitted.
- B. Properties: Complying with guidelines of BHMA A156.28.
 1. Provide small format interchangeable core.
 2. Provide Patented CORMAX keys and cores.
 3. Provide keying information in compliance with DHI (KSN) standards.
 4. Keying Schedule: Arrange for a keying meeting, with Architect, Owner and hardware supplier, and other involved parties to ensure locksets and locking hardware, are functionally correct and keying complies with project requirements.
 5. Keying: Master keyed.
 6. Include construction keying and control keying with removable core cylinders.
 7. Supply keys in following quantities:
 - a. Master Keys: 4 each.
 - b. Construction Master Keys: 6 each.
 - c. Construction Keys: 15 each.
 - d. Construction Control Keys: 2 each.
 - e. Control Keys if New System: 2 each.
 8. Provide key collection envelopes, receipt cards, and index cards in quantity suitable to manage number of keys.
 9. Deliver keys with identifying tags to Owner by security shipment direct from manufacturer.
 10. Permanent Keys and Cores: Stamped with applicable key marking for identification. Do not include actual key cuts within visual key control marks or codes. Stamp permanent keys "Do Not Duplicate."
 11. Include installation of permanent cores and return construction cores to hardware supplier. Construction cores and keys to remain property of hardware supplier.
- C. Products:
 1. Patented:
 - a. CORMAX.

3.20 FINISHES

- A. Finishes: Identified in Hardware Sets.
- B. Exceptions:
 1. Where base material metal is specified to be different, provide finish that is an equivalent appearance in accordance with BHMA A156.18.
 2. Hinges for Fire-Rated Doors: Steel base material with painted finish, in compliance with NFPA 80.
 3. Aluminum Surface Trim and Gasket Housings: Anodized to match door panel finish, not other hardware, unless otherwise indicated.

PART 3 EXECUTION

4.01 EXAMINATION

- A. Verify that doors and frames are ready to receive this work; labeled, fire-rated doors and frames are properly installed, and dimensions are as indicated on shop drawings.
- B. Correct all defects prior to proceeding with installation.
- C. Verify that electric power is available to power operated devices and of correct characteristics.

4.02 INSTALLATION

- A. Install hardware in accordance with manufacturer's instructions and applicable codes.
- B. Install hardware using the manufacturer's fasteners provided. Drill and tap all screw holes located in metallic materials. Do not use "Riv-Nuts" or similar products.

- C. Install hardware on fire-rated doors and frames in accordance with applicable codes and NFPA 80.
- D. Install hardware for smoke and draft control doors in accordance with NFPA 105.
- E. Use templates provided by hardware item manufacturer.
- F. Do not install surface mounted items until application of finishes to substrate are fully completed.
- G. Wash down masonry walls and complete painting or staining of doors and frames.
- H. Complete finish flooring prior to installation of thresholds.
- I. Door Hardware Mounting Heights: Distance from finished floor to center line of hardware item. As indicated in following list, unless noted otherwise in Door Hardware Schedule or on drawings.
 - 1. For Steel Doors and Frames: Install in compliance with DHI (LOCS) recommendations.
 - 2. For Steel Doors and Frames: See Section 6549.
 - 3. For Steel Door Frames: See Section 081213.
 - 4. For Aluminum-Framed Storefront Doors and Frames: See Section 084313.
 - 5. For Wood Doors: Install in compliance with DHI WDHS.3 recommendations.
 - 6. Flush Wood Doors: See Section 081416.
 - 7. Stile and Rail Wood Doors: See Section 081433.
 - 8. Mounting heights in compliance with ADA Standards:
 - a. Locksets: 40-5/16 inch (1024 mm).
 - b. Push Plates/Pull Bars: 42 inch (1067 mm).
 - c. Deadlocks (Deadbolts): 48 inch (1219 mm).
 - d. Exit Devices: 40-5/16 inch (1024 mm).
 - e. Door Viewer: 43 inch (1092 mm); standard height 60 inch (1524 mm).
- J. Set exterior door thresholds with full-width bead of elastomeric sealant at each point of contact with floor providing a continuous weather seal, anchor thresholds with stainless steel countersunk screws.
- K. Include in installation for existing doors and frames any necessary field modification and field preparation of doors and frames for new hardware. Provide necessary fillers, reinforcements, and fasteners for mounting new hardware and to cover existing door and frame preparations.

4.03 FIELD QUALITY CONTROL

- A. Perform field inspection and testing under provisions of Section 014000 - Quality Requirements.
- B. Provide an Architectural Hardware Consultant (AHC) to inspect installation and certify that hardware and installation has been furnished and installed in accordance with manufacturer's instructions and as specified.

4.04 ADJUSTING

- A. Adjust work under provisions of Section 017000 - Execution and Closeout Requirements.
- B. Adjust hardware for smooth operation.
- C. Adjust gasketing for complete, continuous seal; replace if unable to make complete seal.

4.05 CLEANING

- A. Clean finished hardware in accordance with manufacturer's written instructions after final adjustments have been made.
- B. Clean adjacent surfaces soiled by hardware installation activities.
- C. Replace items that cannot be cleaned to manufacturer's level of finish quality at no additional cost.

- D. See Section 017419 - Construction Waste Management and Disposal, for additional requirements.

4.06 PROTECTION

- A. Protect finished Work under provisions of Section 017000 - Execution and Closeout Requirements.
- B. Do not permit adjacent work to damage hardware or finish.

Manufacturer List

Code	Name
BE	Best Access Systems
BY	By Related Section
NA	National Guard
PR	BEST Precision Exit Devices
RC	RCI
ST	BEST Hinges and Sliding
TR	Trimco

Option List

Code	Description
1/4-20 SSMS/EA	Stainless Machine Screws/Expansion Anchors
B4E	Beveled 4 Edges
C	Quick Connect Wiring System
CSK	Counter Sunk Screw Holes
MLR	Motorized Latch Retraction
RQE	Request to Exit
TDS	Touchbar Monitoring Double Switch

Finish List

Code	Description
19	Black Enameled
32D	Satin Stainless Steel
622	Flat Black Coated
693	Black Painted
AL	Aluminum
BL	Black

Hardware Sets

Set #1.0

Doors: A113A, A116D, B113A

6	Butt Hinge	FBF179 4.5" x 4.5" NRP	19	ST
1	Semi-Auto Flushbolt	3820 X 3810	622	TR
1	Office/Entry Lockset	9K3-7AB15C PATD	622	BE
1	Coordinator	3094B2	BL	TR
2	Door Closer - Cush Stop	HD7016 SDS	693	BE
2	Kick Plate	K0050 10" x 1" LDW B4E CSK	622	TR
2	Mounting Bracket	3095	BL	TR
1	Astragal	139SP		NA
1	Weatherstrip	160SDKB Head & Jambs		NA
2	Door Sweep	200NDKB		NA
1	Handicap Threshold	513 1/4-20 SSMS/EA	AL	NA

Set #2.0

Doors: A100A, A100B, A106A, A116B, A116C, B100B, B106A, B110A

2	Butt Hinge	FBF179 4.5" x 4.5" NRP	19	ST
1	Butt Hinge	CEFBF179-54 4.5" x 4.5"	19	ST
1	Electromechanical Lock	9KW3-7DEU15C PATD C RQE	622	BE
1	Door Closer - Cush Stop	HD7016 SDS	693	BE
1	Kick Plate	K0050 10" x 2" LDW B4E CSK	622	TR
1	Card Reader	by Owners Security Integrator		BY
1	Power Supply	DKPS-2A		RC
1	Weatherstrip	160SDKB Head & Jambs		NA
1	Door Sweep	200NDKB		NA
1	Handicap Threshold	513 1/4-20 SSMS/EA	AL	NA

NOTE: Doors are normally closed and locked. Access is gained with valid credentials. Free egress is allowed at all times without use of keys, credentials, special knowledge or effort.

Set #3.0

Doors: A101A, B101A

3	Butt Hinge	FBF179 4.5" x 4.5" NRP	19	ST
1	Exit Device	C MLR TDS 2103 X 4903A	622	PR
1	Door Closer - Cush Stop	HD7016 SDS	693	BE
1	Kick Plate	K0050 10" x 2" LDW B4E CSK	622	TR
1	Card Reader	by Owners Security Integrator		BY
1	Power Supply	RPSMLR2		PR
1	Power Transfer	EPT-12C		PR
1	Weatherstrip	160SDKB Head & Jambs		NA
1	Door Sweep	200NDKB		NA
1	Handicap Threshold	513 1/4-20 SSMS/EA	AL	NA

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DOOR HARDWARE
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NOTE: Doors are normally closed and locked. Access is gained with valid credentials. Free egress is allowed at all times without use of keys, credentials, special knowledge or effort.

Set #4.0

Doors: B114B, B114C

3	Butt Hinge	FBF179 4.5" x 4.5" NRP	19	ST
1	Exit Device - Exit Device	2101	622	PR
1	Door Closer - Cush Stop	HD7016 SDS	693	BE
1	Kick Plate	K0050 10" x 2" LDW B4E CSK	622	TR
1	Weatherstrip	160SDKB Head & Jambs		NA
1	Door Sweep	200NDKB		NA
1	Handicap Threshold	513 1/4-20 SSMS/EA	AL	NA

Set #5.0

Doors: B109B, B111B, B114D

2	Butt Hinge	FBF179 4.5" x 4.5" NRP	19	ST
1	Butt Hinge	CEFBF179-54 4.5" x 4.5"	19	ST
1	Electromechanical Lock	9KW3-7DEU15C PATD C RQE	622	BE
1	Door Closer - Cush Stop	HD7016 SDS	693	BE
1	Kick Plate	K0050 10" x 2" LDW B4E CSK	622	TR
1	Power Supply	DKPS-2A		RC
1	Gasketing	5050 B Head & Jambs		NA
1	Card Reader	by Owners Security Integrator		BY

NOTE: Doors are normally closed and locked. Access is gained with valid credentials. Free egress is allowed at all times without use of keys, credentials, special knowledge or effort.

Set #6.0

Doors: A101B, A108A, B101B, B108A

2	Butt Hinge	FBF179 4.5" x 4.5" NRP	19	ST
1	Butt Hinge	CEFBF179-54 4.5" x 4.5"	19	ST
1	Electromechanical Lock	9KW3-7DEU15C PATD C RQE	622	BE
1	Door Closer Rw/PA	HD7016 AO8P	693	BE
1	Kick Plate	K0050 10" x 2" LDW B4E CSK	622	TR
1	Wall Bumper	1270CVSV	622	TR
1	Card Reader	by Owners Security Integrator		BY
1	Power Supply	DKPS-2A		RC
1	Gasketing	5050 B Head & Jambs		NA

NOTE: Doors are normally closed and locked. Access is gained with valid credentials. Free egress is allowed at all times without use of keys, credentials, special knowledge or effort.

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Set #7.0

Doors: A109B, A116A, B115A, B115B

3	Butt Hinge	FBB179 4.5" x 4.5" NRP	19	ST
1	Lockset	9K3-7W15C PATD	622	BE
1	Electric Strike	2364	32D	RC
1	Door Closer - Cush Stop	HD7016 SDS	693	BE
1	Kick Plate	K0050 10" x 2" LDW B4E CSK	622	TR
1	Card Reader	by Owners Security Integrator		BY
1	Power Supply	DKPS-2A		RC
1	Gasketing	5050 B Head & Jambs		NA

NOTE: Doors are normally closed and locked from both sides. Access/Egress is gained with valid credentials.

Set #8.0

Doors: A111A

5	Butt Hinge	FBB179 4.5" x 4.5" NRP	19	ST
1	Butt Hinge	CEFBB179-54 4.5" x 4.5"	19	ST
1	Semi-Auto Flushbolt	3820 X 3810	622	TR
1	Electromechanical Lock	9KW3-7DEU15C PATD C RQE	622	BE
1	Coordinator	3094B2	BL	TR
2	Door Closer - Cush Stop	HD7016 SDS	693	BE
2	Kick Plate	K0050 10" x 1" LDW B4E CSK	622	TR
2	Mounting Bracket	3095	BL	TR
1	Card Reader	by Owners Security Integrator		BY
1	Power Supply	DKPS-2A		RC
1	Gasketing	5050 B Head & Jambs		NA
1	Astragal	139SP		NA

NOTE: Doors are normally closed and locked. Access is gained with valid credentials. Free egress is allowed at all times without use of keys, credentials, special knowledge or effort.

Set #9.0

Doors: B104A, B105A

3	Butt Hinge	FBB179 4.5" x 4.5"	19	ST
1	Pull Plate	1017-3B	622	TR
1	Push Plate	1001-9	622	TR
1	Door Closer Rw/PA	HD7016 AO8P	693	BE
1	Kick Plate	K0050 10" x 2" LDW B4E CSK	622	TR
1	Wall Bumper	1270CVSV	622	TR
1	Gasketing	5050 B Head & Jambs		NA

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DOOR HARDWARE
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Set #10.0

Doors: A102A, A103A, A109A, A112A, B102A, B103A, B109A, B112A

3	Butt Hinge	FBB179 4.5" x 4.5"	19	ST
1	Office/Entry Lockset	9K3-7AB15C PATD	622	BE
1	Wall Bumper	1270CVSV	622	TR
1	Gasketing	5050 B Head & Jambs		NA

Set #11.0

Doors: A107A, B107A

3	Butt Hinge	FBB179 4.5" x 4.5"	19	ST
1	Lockset	9K3-7D15C PATD	622	BE
1	Wall Bumper	1270CVSV	622	TR
1	Gasketing	5050 B Head & Jambs		NA

Set #12.0

Doors: A104A, A105A

3	Butt Hinge	FBB179 4.5" x 4.5"	19	ST
1	Privacy Set	9K3-0L15C	622	BE
1	Wall Bumper	1270CVSV	622	TR
1	Gasketing	5050 B Head & Jambs		NA

END OF SECTION

SECTION 08 7113 - AUTOMATIC DOOR OPERATORS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes Low-energy door operators for swinging doors; wall mounted and pedestal mounted. Exact doors to receive automatic door operators to be determined by Architect of Record.

1.2 DEFINITIONS

- A. AAADM: American Association of Automatic Door Manufacturers.
- B. Activation Device: A control that, when actuated, sends an electrical signal to the door operator to open the door.
- C. Double-Egress (Doors): A pair of doors that simultaneously swing with the two doors moving in opposite directions with no mullion between them.
- D. Double-Swing (Doors): A pair of doors that swing with the two doors moving in opposite directions with a mullion between them; each door functioning as a single-swing door.
- E. Safety Device: A control that, to avoid injury, prevents a door from opening or closing.
- F. For automatic door terminology, see BHMA A156.19 for definitions of terms

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project Site.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For automatic door operators.
 - 1. Include plans, elevations, sections, hardware mounting heights, and attachment details.
 - 2. Include diagrams for power, signal, and control wiring.
- C. Samples: For each exposed product and for each color and texture specified.

1.5 INFORMATIONAL SUBMITTALS

- A. Product certificates.
- B. Field quality-control reports.
- C. Sample warranties.

1.6 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of automatic door operators that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Provided compliance with requirements, products of the following manufacturers will also be acceptable:
 - 1. ASSA Abloy Entrance Systems, Inc.
 - 2. DORMA Architectural Hardware.
 - 3. Dor-O-Matic, Inc.; an Allegion Company.
 - 4. Horton Automatics, Division of Overhead Door Corp.
 - 5. Nabco Entrances, Inc.

2.2 AUTOMATIC DOOR OPERATORS, GENERAL

- A. General: Provide operators of size recommended by manufacturer for door size, weight, and movement; for condition of exposure; and for long-term, maintenance-free operation under normal traffic load for occupancy type indicated; and in accordance with UL 325. Coordinate operator mechanisms with door operation, hinges, and activation and safety devices.
 - 1. Fire-Rated Doors: Provide door operators for fire-rated door assemblies that comply with NFPA 80 for fire-rated door components and are listed and labeled by a qualified testing agency.
 - 2. Wind Load: Provide door operators on exterior doors that will open and close doors and maintain them in fully closed position when subjected to design wind loads.
- B. Electromechanical Operating System: Self-contained unit powered by permanent-magnet dc motor; with closing speed controlled mechanically by gear train and dynamically by braking action of electric motor, connections for power and activation- and safety-device wiring, and manual operation, including spring closing when power is off.
- C. Cover for Surface-Mounted Operators: Fabricated from 0.125-inch- (3.2-mm-) thick, extruded or formed aluminum; continuous over full width of operator-controlled door opening with enclosed end caps, provision for maintenance access, and fasteners concealed when door is in closed position.
- D. Brackets and Reinforcements: Fabricated from aluminum with nonstaining, nonferrous shims for aligning system components.
- E. Fire-Door Package: Consisting of UL-listed latch mechanism, power-reset box, and caution signage for fire-rated doors.
 - 1. Provide latch mechanism that allows door to swing free during automatic operation; when fire is detected.
 - 2. Provide latch actuator that causes exit hardware to latch when door closes.
 - 3. Provide latch actuators with fail-secure design.
- F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- G. Provide product data or letter from manufacturer that confirms that the product has no asbestos, and no added lead more than 100 ppm.

2.3 LOW-ENERGY DOOR OPERATORS FOR SWINGING DOORS

- A. Standard: BHMA A156.19.
- B. Performance Requirements:
 - 1. Opening Force if Power Fails: Not more than 15 lbf (67 N) required to release latch if provided, not more than 30 lbf (133 N) required to manually set door in motion, and not more than 15 lbf (67 N) required to fully open door.
 - 2. Entrapment-Prevention Force: Not more than 15 lbf (67 N) required to prevent stopped door from closing or opening.
- C. Configuration: Operator to control swinging doors.
 - 1. Traffic Pattern: One way.
 - 2. Operator Mounting: Surface.
- D. Operating System: Electromechanical.
- E. Microprocessor Control Unit: Solid-state controller.
- F. Features:
 - 1. Adjustable opening and closing speed and force.
 - 2. Adjustable backcheck.
 - 3. Adjustable hold-open time from zero to 30 seconds.
 - 4. Obstruction recycle.
 - 5. On-off/hold-open switch to control electric power to operator; key operated.
- G. Activation Device: Push-plate switch on each side of door to activate door operator.

2.4 MATERIALS, GENERAL:

- A. Provide only products in this Section with low VOC content.
- B. Provide biobased material as per Sustainable Agriculture Network's Sustainable Agriculture Standard or USDA certified biobased product and tested in accordance with ASTM D6866 or ISO 16620-2.
- C. Provide product data or letter from manufacturer that confirms that the product has no asbestos, and no added lead more than 100 ppm.

2.4 MATERIALS

- A. Aluminum: Alloy and temper recommended by manufacturer for type of use and finish indicated.
 - 1. Extrusions: ASTM B221 (ASTM B221M).
 - 2. Sheet: ASTM B209 (ASTM B209M).
- B. Fasteners and Accessories: Corrosion-resistant, nonstaining, nonbleeding fasteners and accessories compatible with adjacent materials.

2.5 CONTROLS

- A. General: Provide controls in accordance with BHMA standards; for condition of exposure; and for long-term, maintenance-free operation under normal traffic load for occupancy type indicated. Coordinate devices with door operation and door operator mechanisms.
- B. Push-Plate Switch: Momentary-contact door control switch with flat push-plate actuator with contrasting-colored, engraved message.
 - 1. Configuration: Square push plate with 4-by-4-inch (100-by-100-mm) junction box.
 - a. Mounting: Recess mounted, semiflush in wall.
 - 2. Push-Plate Material: Stainless steel.
 - 3. Message: International symbol of accessibility and "Push to Open."
- C. Electrical Interlocks: Unless units are equipped with self-protecting devices or circuits, provide electrical interlocks to prevent activation of operator when door is locked, latched, or bolted.
- D. Signage: Comply with cited BHMA standard for type of door and its operation.
 - 1. Application Process: Operator manufacturer's standard process.
 - 2. Provide sign materials with instructions for field application when operators are installed.
- E. Pedestal Mount: Security Door Controls, "Model BPG6 54" In-Ground, 6" Square Post" with following features:
 - 1. For use with Push Plates specified herein.
 - 2. Size: 6" square with 1/8" wall thickness.
 - 3. Black HDPE Mortised Removable Cap with secure transmitter mount.
 - 4. Standard Single Gang Prep Located at 36" from Finished Floor
 - 5. Weight: 11.0 lbs.
 - 6. Finish: V 628 Aluminum (standard)

2.6 FABRICATION

- A. Factory fabricate automatic door operators to comply with indicated standards.
- B. Fabricate exterior components to drain condensation and water-passing joints within operator enclosure to the exterior.
- C. Use concealed fasteners to greatest extent possible. Where exposed fasteners are required, use countersunk Phillips flat-head machine screws, finished to match operator.

2.7 FINISHES, GENERAL

- A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
- B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

- C. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.8 ALUMINUM FINISHES

- A. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
- B. Finish: As selected by Architect.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions, with installer present, for compliance with requirements for installation tolerances, door and frame supports, and other conditions affecting performance of automatic door operators.
- B. Examine roughing-in for electrical systems to verify actual locations of power connections before automatic door operator installation

3.2 INSTALLATION, GENERAL

- A. Install automatic door operators in accordance with manufacturer's written instructions and cited BHMA standard for type of door operation and direction of pedestrian travel, including signage, controls, wiring, remote power units if any, and connection to building's power supply.
- B. Verify that full-height finger guards are installed at each door with a clearance at hinge side greater than 1/4 inch (6 mm) and less than 3/4 inch (19 mm) with door in any position.
- C. Controls: Install devices in accordance with manufacturer's written instructions and cited BHMA standard for operator type and direction of pedestrian travel.
- D. Signage: Apply on both sides of each door as required by cited BHMA standard for type of door operator and direction of pedestrian travel.

3.3 FIELD QUALITY CONTROL

- A. Certified Inspector: Engage a Certified Inspector to test and inspect components, assemblies, and installations, including connections.

- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Test and inspect each automatic door operator installation, using AAADM inspection forms, to determine compliance of installed systems with applicable BHMA standards.
 - 2. Automatic door operators will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.4 ADJUSTING

- A. Adjust automatic door operators and activation and safety devices to operate smoothly and for safe operation and weathertight closure.
 - 1. Adjust doors with low-energy door operators to close according to BHMA A156.19.
- B. Lubricate operators, hardware, and other moving parts.
- C. After installation, inspect exposed finishes and repair damaged finishes.
- D. Readjust automatic door operators and activation and safety devices after repeated operation of completed installation equivalent to three days' use by normal traffic (100 to 300 cycles).
- E. Occupancy Adjustment: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose, without additional cost.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain automatic door operators.

END OF SECTION

SECTION 08 8000 - GLAZING

PART 1 - GENERAL

1.1 SUMMARY:

- A. Related work:
 - 1. Joint sealants.
 - 2. Aluminum-framed entrances and storefronts.
 - 3. Aluminum-framed punched openings and curtain walls.
- B. Definitions:
 - 1. Normal vision area: For purposes of defining quality standards for reflective glass, "normal vision area" shall be glass located between 1'-0" off finish floor and 7'-0" vertically and horizontally to within 3" of mullions.

1.2 ACTION SUBMITTALS:

- A. Samples: Submit minimum 1'-0" by 1'-0" samples of each type glazing material proposed for use, if requested by Architect.
- B. Product data: Submit for each type of glazing material and accessory product specified. Include technical data, storage and handling procedures and performance characteristics.
- C. Calculations: Submit for Architect's information only.
 - 1. Submit calculations prepared by glazing material manufacturer indicating recommendations for glass thickness and heat treating of glazing materials as a result of heat stress, building orientation, inside window treatments, shading by exterior building components or wind loading.
 - 2. Identify factors affecting breakage probability which have been taken into consideration and breakage probability anticipated by calculations.

1.3 INFORMATIONAL SUBMITTALS:

- A. Framing manufacturer's approval: Prior to submission of shop drawings, indicate by letter that an authorized representative of storefront and window framing manufacturer has reviewed and approved details, including glass bite, clearances and glazing methods.

1.4 CLOSEOUT SUBMITTALS:

- A. Maintenance data: Submit glazing material manufacturer's maintenance data for cleaning and care of each type of glazing material.

1.5 QUALITY ASSURANCE:

- A. Applicable standards:
 - 1. American National Standards Institute (ANSI), "Safety Performance Standards and Methods of Tests for Safety Glazing Materials used in Buildings," Z97.1.
 - 2. ASTM International (ASTM), standards as referenced herein.
 - 3. Consumer Product Safety Commission (CPSC), "Safety Standard for Architectural Glazing Materials," 16-CFR, Chapter II, Part 1201.
 - 4. Glass Association of North America (GANA) "Glazing Manual".
- B. Design criteria:
 - 1. Wind Loads; ASCE 7:
 - a. Wind loads for an ultimate wind speed of 150 mph 3-second gust.
 - b. Exposure: Exposure B.
 - c. Risk Category: III (ASCE 7 Method).
 - 2. Thermal insulated units: Units shall comply with the requirements of ASTM E2190-10 and be certified by Associated Laboratories, Inc., (ALI) or Insulating Glass Certification Council (IGCC) for Class A.

3. Tempered and heat-treated glass:
 - a. Glazing materials, whether in monolithic state or as a lite of a thermal insulated unit, shall be tempered or otherwise heat-treated where required by glass manufacturer's design calculations to resist stress caused by glass orientations, sizes and configurations, heat stress, inherent imperfections, wind loading, glazing conditions, temperature differential, inside window treatments or other conditions affecting breakage probability.
 - b. Orient lites with roll distortion parallel to head and sill members.
 - c. Maximum allowable breakage probability at design loads shall be eight lites per thousand for vertical glazing.
 4. Tempered and laminated glazing materials shall comply with CPSC 16-CFR, Part 1201, Category II.
 5. Safety glazing: Tempered and human impact safety and fire-resistance-rated glazing materials shall comply with safety glazing requirements of CPSC 16-CFR, Part 1201, Category II, with testing requirements of ASTM C1048-12, and with code requirements for locations of safety glazing.
 6. At design wind pressure loading, deflection at center of structural silicone glazed units shall not exceed 3/4".
 7. Quality standards for spandrel glass; viewed against bright, uniform background:
 - a. Color uniformity and reflectance: Slight variation, as determined by Architect, is allowable, viewed from a distance of 10'-0".
 - b. Pinholes: Pinholes greater than 1/16" diameter not allowable. Clusters of pinholes, each smaller than 1/16" diameter, not allowable if visible from a distance of 6'-0".
 - c. Scratches: Scratches exceeding 3" long not allowable in normal vision areas of reflective glass. Scratches longer than 3" not allowable outside normal vision areas if visible from a distance of 10'-0" in spandrel glass.
- C. Labeling: Safety glazing labeling: Permanently mark safety glazing with a certification label of a certifying agency acceptable to authorities having jurisdiction. Label shall indicate manufacturer's name, type of glass, thickness, and safety glazing standard with which glass complies.

1.6 DELIVERY, STORAGE AND HANDLING:

- A. Store glazing materials indoors in cool, dry area, off floor, supported to prevent stress and breakage.
- B. Move no cases which have been partially unpacked. Unpack glazing materials in accord with manufacturer's product data for type of material being handled. Stack individual lites as recommended by manufacturer's product data.
- C. Utilize rolling blocks to rotate glazing materials.
- D. Handle insulated units without rotating, warping or "cartwheeling" units. Prevent damage to glazing material or edge seal.

1.7 WARRANTIES:

- A. Manufacturer's Warranty on Coated Glass Products: Submit written warranty signed by coated glass manufacturer agreeing to furnish replacements for those coated glass units that deteriorate within specified warranty period indicated below. Warranty covers only deterioration due to normal conditions of use and not to handling, installing, and cleaning practices contrary to glass manufacturer's published instructions.
 1. Warranty Period: Manufacturer's standard but not less than 10 years after date of Substantial Completion.
- B. Manufacturer's Warranty on Insulating Glass: Submit written warranty signed by insulating glass manufacturer agreeing to furnish replacements for insulating glass units that deteriorate within specified warranty period indicated below. Warranty covers only deterioration due to normal conditions of use and not to handling, installing, protecting, and maintaining practices contrary to glass manufacturer's published instructions.

1. Warranty Period: Manufacturer's standard but not less than 10 years after date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

- A. Acceptable float glass manufacturers; subject to compliance with specified requirements:
 1. AGC Flat Glass North America.
 2. Guardian Industries Corp.
 3. Pilkington, Building Products North America.
 4. Basis of design; Vitro Architectural Glass, (Formerly PPG Industries, Inc./Glass Group.)
- B. Acceptable glass unit fabricators; subject to compliance with specified requirements:
 1. Oldcastle Building Envelope™.
 2. Trulite Glass & Aluminum Solutions (formerly Arch Aluminum and Glass and Vitro America.)
 3. Viracon, Inc.
- C. Acceptable low-emissivity (Low-E) glass fabricators; subject to compliance with specified requirements:
 1. Guardian Industries Corp.
 2. Oldcastle Building Envelope™.
 3. Pilkington, Building Products North America.
 4. PPG Industries, Inc./Glass Group.
 5. Viracon, Inc.
 6. Basis of design; Vitro Architectural Glass, (Formerly PPG Industries, Inc./Glass Group.)
- D. Performance for basis of design clear tempered thermal insulating units:
 1. Basis of design for thermal insulated units: Vitro, "Solarban® Solar Control Low-E Glass, Solarban® 90 (2) Clear + Clear".
 2. Performance characteristics:
 - a. Visible light transmittance: 51%.
 - b. Visible light reflectance:
 - 1) Exterior: 12%.
 - 2) Interior: 19%.
 - c. U Value winter night: 0.29.
 - d. Solar Heat Gain Coefficient (SHGC): 0.23.
 - e. Light to solar gain ratio (LSG): 2.22.

2.2 GLAZING MATERIALS:

- A. General flat glass standard: Comply with ASTM C1036-11 as follows:
 1. Transparent flat glass, clear: Type I, Class 1-Clear, Quality - Q3.
 2. Mirrors: Type I, Class 1-Clear, Quality - Q1.
- B. Clear monolithic glass:
 1. GL-4; Tempered monolithic glass: 1/4" thickness, fully tempered, complying with ASTM C1048-12.
 2. Non-tempered monolithic glass: 1/4" thickness, complying with ASTM C1036-11.
- C. GL-1; Thermal insulated units: Both lites tempered.
 1. Inboard lite: Clear, tempered float glass; 1/4" thickness.
 2. Outboard lite: Clear, tempered float glass; 1/4" thickness. Provide "Solar Control Low-E Glass, Solarban® 90 (2)" Low-E coating on #2 surface.
 3. Unit thickness: 1" minimum.
 4. Spacer: Manufacturer's standard steel or aluminum spacer with welded, soldered, fused or bent corners and welded, soldered or fused splices and joints, filled with desiccant; to provide a 1/2" thickness, hermetically sealed, dehydrated air space.

- D. GL-2; Thermal insulated units: Heat-strengthened.
 - 1. Inboard lite: Clear, float glass; 1/4" thickness.
 - 2. Outboard lite: 1/4" thickness float glass. Provide "Solar Control Low-E Glass, Solarban® 90 (2)" Low-E coating on #2 surface.
 - 3. Unit thickness: 1" minimum.
 - 4. Spacer: Manufacturer's standard steel or aluminum spacer with welded, soldered, fused or bent corners and welded, soldered or fused splices and joints, filled with desiccant; to provide a 1/2" thickness, hermetically sealed, dehydrated air space.
- E. GL-3; Tempered insulated spandrel units: Both lites tempered.
 - 1. Inboard lite: Clear tempered float glass; 1/4" thick glass with Opaci Coat 300#-1525 Stone Wall (LI) on #3 surface of clear tempered float glass.
 - 2. Outboard lite: Vitro "Solarban® 90" low-e coating on #2 surface of clear tempered float glass; 1/4" thick.
 - 3. Unit thickness: 1" minimum.
 - 4. Spacer: Manufacturer's standard steel or aluminum (black) spacer with welded, soldered, fused or bent corners and welded, soldered or fused splices and joints, filled with desiccant; to provide a 1/2" thickness, hermetically sealed, dehydrated air space.
- F. Laminated glass: 9/16" thickness, fully tempered laminated, complying with ASTM C1048-12, formed from two sheets of 1/4" thickness tempered glass laminated with polyvinyl butyral (PVB) interlayer; nominal 9/16" lite thickness.
- G. Unframed mirrors: 1/4" thickness, Mirror Select Quality plate or float glass with silver coating and electrolytically copper-plated back.
 - 1. Grind and polish edges to be exposed in finished work and edges for butt joints.

2.3 GLAZING SEALANTS:

- A. General:
 - 1. Compatibility: Provide glazing sealants that are compatible with one another and with other materials they will contact, including glass products, seals of insulating-glass units, and glazing channel substrates, under conditions of service and application, as demonstrated by sealant manufacturer based on testing and field experience.
 - 2. Suitability: Comply with sealant and glass manufacturers' written instructions for selecting glazing sealants suitable for applications indicated and for conditions existing at time of installation.
 - 3. Sealants used inside the weatherproofing system, shall have a VOC content of not more than 250 g/L when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. Glazing sealant for structural glazing:
 - 1. Acceptable products:
 - a. Dow Corning Corp., DOWSIL #795 Silicone Building Sealant.
 - b. Pecora, Corp., 895.
 - c. Tremco, Inc., Proglaze SSG.
 - 2. Characteristics: One-part silicone rubber; black color for structural glazing.
 - 3. Provide primers as required by adhesion testing, backer rod and accessories acceptable to sealant manufacturer.
- C. Glazing sealant for weather seal in structural glazing:
 - 1. Acceptable products:
 - a. Dow Corning Corp., DOWSIL #999A Silicone Building Sealant.
 - b. Pecora, Corp., 860.
 - c. Tremco, Inc., Proglaze.
 - 2. Characteristics: One-part silicone rubber; black color for structural glazing.
 - 3. Provide primers as required by adhesion testing, backer rod and accessories acceptable to sealant manufacturer.

2.4 GLAZING ACCESSORIES:

- A. Setting blocks for full rabbet glazing: Neoprene, 70-90 Shore A durometer hardness, meeting ASTM C864-05(2011).
- B. Setting blocks for structural glazing: Type II, preformed silicone rubber, 80 Shore A durometer hardness.
- C. Edge blocks for full rabbet glazing: Neoprene, 60-70 Shore A durometer hardness, meeting ASTM C864-05(2011).
- D. Spacers for full rabbet glazing: Neoprene, 40-50 Shore A durometer hardness, meeting ASTM C864-05(2011).
- E. Spacers for structural glazing: Type I, preformed silicone rubber, 50 Shore A durometer hardness.
- F. Glazing gaskets: Premium quality sealed-corner pressure-glazing system of black, resilient elastomeric glazing gaskets, setting blocks, and shims or spacers. Gaskets shall be as recommended by framing system manufacturer to meet specified framing system performance criteria and framing system warranty requirements.
 - 1. Dense compression gaskets: Molded or extruded gaskets of profile and hardness required to maintain watertight seal, made from one of the following:
 - a. Neoprene complying with ASTM C864-05(2011).
 - b. EPDM complying with ASTM C864-05(2011).
 - c. Silicone complying with ASTM C1115-06.
 - d. Thermoplastic polyolefin rubber complying with ASTM C1115-06.
 - 2. Soft compression gaskets:
 - a. Type: Extruded or molded, closed-cell, integral-skinned neoprene, EPDM, silicone or thermoplastic polyolefin rubber gaskets complying with ASTM C509-06(2011), Type II, black; of profile and hardness required to maintain watertight seal.
 - b. Application: Use where soft compression gaskets will be compressed by inserting dense compression gaskets on opposite side of glazing or pressure applied by means of pressure-glazing stops on opposite side of glazing.
 - 3. Lock-strip gaskets: Neoprene extrusions in size and shape indicated, fabricated into frames with molded corner units and zipper lock-strips, complying with ASTM C542-05(2011), black.
- G. Glazing gaskets for structural glazing:
 - 1. Exterior gaskets: Type II, preformed silicone rubber sponge, 50 Shore A hardness, black color.
 - 2. Interior gaskets: Type II, preformed silicone rubber wedge, 70 Shore A hardness, black color.
- H. Polyvinyl chloride foam tape for interior glazing: Closed cell self-adhesive tape meeting ASTM D1667-05(2011).
- I. Mirror adhesive:
 - 1. Acceptable products:
 - a. CRL Gunther Premier Plus Ultra Low VOC Mirror Mastic.
 - b. Franklin International, Titebond Division, Titebond Greenchoice Premium Polyurethane Construction Adhesive.
 - c. Liquid Nails, Adhesive LN-730.
 - 2. Type: An adhesive setting compound, produced specifically for setting mirrors and certified by both mirror manufacturer and mastic manufacturer as compatible with glass coating and substrates on which mirrors will be installed.
 - 3. Adhesive shall have a VOC content of not more than 70 g/L when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- J. Mirror channel: C.R. Laurence Co., Inc., D636A; natural anodized aluminum J-channel, 3/8" face, full mirror length.

PART 3 - EXECUTION

3.1 EXAMINATION:

- A. Verify compliance with the following requirements prior to beginning glazing work:
 - 1. That framing is anchored in position, plumb and square within 1/8" of nominal dimensions indicated.
 - 2. That fastener heads, and other projections are removed from glazing rabbets.
 - 3. That corners and fabrication intersections are sealed and framing is weathertight.
 - 4. That rabbets at sills weep to outside and rabbets are of sufficient depth and width to receive glazing material and provide the required bite of the glazing material.
 - 5. That surfaces to receive zipper type gaskets comply with tolerances required by gasket manufacturer.
 - 6. That wood frames have received prime paint coat in accord with Section 09 9100 - Painting and Coating.

3.2 PRE-GLAZING CONFERENCE:

- A. Prior to beginning glass and glazing work, a preglazing conference will be held to review work to be accomplished.
- B. Contractor, Architect, storefront and window wall supplier and erector, a representative of glass manufacturer, a representative of sealant manufacturer and glazing subcontractor will be present.
- C. Contractor shall notify all parties at least seven days prior to time of conference.
- D. Material submitted by Contractor, interfacing of glass and glazing and window wall work, dimensions and tolerances, sealant joint widths and depths shall be reviewed.

3.3 PERFORMANCE REQUIREMENTS:

- A. Install glazing materials to obtain airtight and watertight installation and to withstand normal temperature changes and wind loads without failure.
- B. Protect glazing material faces and edges during handling and installation.
- C. Size glazing materials for each opening to ensure correct bite on glazing material, without imposing strain, in accord with manufacturer's product data.
- D. Maintain minimum bed clearance between glazing material and sash of 1/8", both sides, except where greater clearance is required by either glazing material or framing manufacturer.

3.4 PREPARATION OF SURFACES:

- A. Clean glass edges and framing glazing channel of debris and protective coatings immediately prior to glazing. Use material acceptable to framing, glazing material and glazing sealant manufacturers.
- B. Inspect glazing material prior to installation. Eliminate lites having face or edge damage.
- C. Lites of tempered and insulated glass shall not be cut or otherwise altered in the field.

3.5 GLAZING PROCEDURES:

- A. Install glazing materials in accord with manufacturer's product data and applicable standards, except where more stringent requirements are specified.
- B. Install setting blocks for glazing materials over six sq. ft. in area. Install at sill rabbet at quarter points. Size setting blocks in proportion to glass weight; minimum 4" length.
- C. Shim lites over 100 united inches, inboard and outboard, on all sides using continuous shims, except where gaskets accomplish shimming.

- D. Structural glazing, two-sided: Glaze in accord with framing system manufacturer's product data, using silicone rubber glazing gaskets and glazing accessories and silicone sealant as specified.
1. Install gaskets at exterior gasket pocket. Index gaskets into framing. Install setting blocks as herein specified.
 2. Install temporary glass retainer clips as required by system design; minimum of three clips along each structurally glazed edge.
 3. Center glass in rabbet, setting against retainer clips.
 4. Install interior gasket around full perimeter of gasket pocket as indicated on approved shop drawings.
 5. Using retainer clips, install remaining lites in sequence in accord with system manufacturer's product data.
 6. Apply interior structural silicone sealant and exterior weather seal in accord with sequence and procedures recommended by product data to fill and seal joints. At two-sided structurally glazed units ensure that exterior weather seal is adhered to exterior gaskets. Do not allow weather seal sealant to contact thermal insulated unit edge seal.
- E. Except at structural glazing, provide edge blocks at vertical jambs to prevent lateral movement of glass. Provide edge blocks at 3" minimum length. Maintain 1/8" clearance between edge of glass and edge block.
- F. Glazing gaskets (dry): Install gaskets in accord with framing system manufacturer's installation requirements, to meet specified framing system performance criteria and framing system watertight warranty.
1. Cut compression gaskets to lengths recommended by gasket manufacturer to fit openings exactly, with allowance for stretch during installation.
 2. Insert soft compression gasket between glass and frame or fixed stop so it is securely in place. Joints shall be miter cut and bonded together.
 3. Installation with drive-in wedge gaskets: Center glass lites in openings on setting blocks and press firmly against soft compression gaskets by inserting dense compression gaskets formed and installed to lock in place against faces of removable stops. Start gasket applications at corners and work toward centers of openings. Compress gaskets to produce a weathertight seal without developing bending stresses in glass. Seal gasket joints with sealant recommended by gasket manufacturer.
 4. Installation with pressure-glazing stops: Center glass lites in openings on setting blocks and press firmly against soft compression gasket. Install dense compression gaskets and pressure-glazing stops, applying pressure uniformly to compression gaskets. Compress gaskets to produce a weathertight seal without developing bending stresses in glass. Seal gasket joints with sealant recommended by gasket manufacturer.
 5. Install gaskets so they protrude past face of glazing stops.
- G. Glazing sealant installation: Comply with applicable provisions of Section 07 9200 - Joint Sealants. Prevent filling of weep holes with sealant.
- H. Exterior channel glazing for lites over 100 united inches: Glaze using preshimmed butyl polyisobutylene tape outboard; glazing gasket inboard. Cut tape to size and apply to exterior stop, placing so that top edge is flush with sight line. Apply tape to horizontal members first, then to verticals, with tight, butted joints. Center glazing material in rabbet. Apply stop and install continuous sealant seal. Secure glazing material with continuous gasket, mitered at corners.
- I. Mirrors: Provide continuous mirror channel along bottom edge of mirror. Secure with toggle bolts at 1'-4" o. c., maximum. Install mirror bottom in channel, mirror back using adhesive in accord with manufacturer's product data.

3.6 PROTECTION AND CLEANING:

- A. For glazing materials subject to damage during construction, protect from breakage by attachment of crossed streamers to framing. Do not mark on surfaces.

- B. Remove and replace broken, cracked, chipped or otherwise damaged glazing materials and materials not meeting specified design criteria prior to Date of Substantial Completion.
- C. Final cleaning: Just prior to Date of Substantial Completion, clean glass inside and out. Clean using pre-tested detergent and water. Flush with clean water. Repair or replace work which cannot be cleaned or which has been damaged during construction operations.

END OF SECTION

SECTION 092200 - SUPPORTS FOR PLASTER AND GYPSUM BOARD

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced.
The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A463/A463M	(2010; R 2015) Standard Specification for Steel Sheet, Aluminum-Coated, by the Hot-Dip Process
ASTM A653/A653M	(2019) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM C645	(2014; E 2015) Nonstructural Steel Framing Members
ASTM C754	(2018) Standard Specification for Installation of Steel Framing Members to Receive Screw-Attached Gypsum Panel Products

UNDERWRITERS LABORATORIES (UL)

UL Fire Resistance	(2014) Fire Resistance Directory
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1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Metal Support Systems

Recycled Content for Metal Support Systems

1.3 DELIVERY, STORAGE, AND HANDLING

Deliver materials to the job site and store in ventilated dry locations permitting easy access for inspection and handling. If materials are stored outdoors, stack materials off

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the ground, supported on a level platform, and fully protected from the weather. Handle materials carefully to prevent damage. Remove damaged items and provide new items.

PART 2 PRODUCTS

2.1 MATERIALS

Provide steel materials for metal support systems with galvanized coating ASTM A653/A653M, G-60; aluminum coating ASTM A463/A463M, T1-25; or a 55-percent aluminum-zinc coating.

Provide metal support systems containing a minimum of 20 percent recycled content.
Provide data identifying percentage of recycled content for metal support systems.

2.1.1 Materials for Attachment of Gypsum Wallboard

2.1.1.1 Suspended and Furred Ceiling Systems

ASTM C645.

2.1.1.2 Non-load Bearing Wall Framing and Furring

ASTM C645, but not thinner than 0.0179 inch thickness, with 0.0329 inch minimum thickness supporting wall hung items such as cabinetwork, equipment and fixtures.

2.1.1.3 Furring Structural Steel Columns

ASTM C645. Steel (furring) clips and support angles listed in UL Fire Resistance may be provided in lieu of steel studs for erection of gypsum wallboard around structural steel columns.

2.1.1.4 Z-Furring Channels with Wall Insulation

Not lighter than 26 gage galvanized steel, Z-shaped, with 1-1/4 inch and 3/4 inch flanges and depth as required by the insulation thickness provided.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Systems for Attachment of Gypsum Wallboard

3.1.1.1 Suspended and Furred Ceiling Systems

ASTM C754, except provide framing members 16 inches o.c. unless indicated otherwise.

3.1.1.2 Non-load Bearing Wall Framing and Furring ASTM

C754, except as indicated otherwise.

3.1.1.3 Furring Structural Steel Columns

Install studs or galvanized steel clips and support angles for erection of gypsum wallboard around structural steel columns in accordance with the UL Fire Resistance, design number(s) of the fire resistance rating indicated.

3.1.1.4 Z-Furring Channels with Wall Insulation

Install Z-furring channels vertically spaced not more than 24 inches o.c. Locate Z-furring channels at interior and exterior corners in accordance with manufacturer's printed erection instructions. Fasten furring channels to masonry walls with powder-driven fasteners or hardened concrete steel nails through narrow flange of channel. Space fasteners not more than 24 inches o.c.

3.2 ERECTION TOLERANCES

Provide framing members which will be covered by finish materials such as wallboard, plaster, or ceramic tile set in a mortar setting bed, within the following limits:

- a. Layout of walls and partitions: 1/4 inch from intended position;
- b. Plates and runners: 1/4 inch in 8 feet from a straight line;
- c. Studs: 1/4 inch in 8 feet out of plumb, not cumulative; and
- d. Face of framing members: 1/4 inch in 8 feet from a true plane.

Provide framing members which will be covered by ceramic tile set in dry-set mortar, latex-portland cement mortar, or organic adhesive within the following limits:

- a. Layout of walls and partitions: 1/4 inch from intended position;
- b. Plates and runners: 1/8 inch in 8 feet from a straight line;
- c. Studs: 1/8 inch in 8 feet out of plumb, not cumulative; and
- d. Face of framing members: 1/8 inch in 8 feet from a true plane.

-- End of Section --

SECTION 092216 - NON-STRUCTURAL METAL FRAMING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

1. Non-load-bearing steel framing systems for interior partitions.
2. Suspension systems for interior ceilings and soffits.
3. Grid suspension systems for gypsum board ceilings.

- B. Related Requirements:

1. Section 054000 "Cold-Formed Metal Framing" for exterior and interior load-bearing and exterior non-load-bearing wall studs; floor joists; and roof rafters and ceiling joists.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each type of code-compliance certification for studs and tracks.
- B. Evaluation Reports: For **[embossed, high-strength steel studs and tracks] [firestop tracks] [post-installed anchors] [and] [power-actuated fasteners]**, from ICC-ES or other qualified testing agency acceptable to authorities having jurisdiction.

1.5 QUALITY ASSURANCE

- A. Code-Compliance Certification of Studs and Tracks: Provide documentation that framing members are certified according to the product-certification program of **the Certified Steel Stud Association, the Steel Framing Industry Association, or the Steel Stud Manufacturers Association.**

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Fire-Test-Response Characteristics: For fire-resistance-rated assemblies that incorporate non-load-bearing steel framing, provide materials and construction identical to those tested in assembly indicated, according to ASTM E119 by an independent testing agency.
- B. STC-Rated Assemblies: For STC-rated assemblies, provide materials and construction identical to those tested in assembly indicated on Drawings, according to ASTM E90 and classified according to ASTM E413 by an independent testing agency.
- C. Horizontal Deflection: For **[composite] [non-composite]** wall assemblies, limited to **[1/240] [1/360]** of the wall height based on horizontal loading of **10 lbf/sq. ft. (480 Pa)**.

2.2 FRAMING SYSTEMS

- A. Framing Members, General: Comply with ASTM C754 for conditions indicated.
 - 1. Steel Sheet Components: Comply with ASTM C645 requirements for steel unless otherwise indicated.
 - 2. Protective Coating: **[ASTM A653/A653M, G40 (Z120)]**, hot-dip galvanized unless otherwise indicated.
- B. Studs and Tracks: ASTM C645. **[Use either conventional steel studs and tracks or embossed, high-strength steel studs and tracks.]**
 - 1. Steel Studs and Tracks:
 - a. Minimum Base-Steel Thickness: **As required by performance requirements for horizontal deflection 0.0179 inch (0.455 mm)**.
 - b. Depth: **As indicated on Drawings**.
 - 2. Embossed, High Strength Steel Studs and Tracks: Roll-formed and embossed with surface deformations to stiffen the framing members so that they are structurally comparable to conventional ASTM C645 steel studs and tracks.
 - a. Minimum Base-Steel Thickness: **As required by horizontal deflection performance requirements**.
 - b. Depth: **As indicated on Drawings**.
- C. Slip-Type Head Joints: Where indicated, provide **[one of]** the following:
 - 1. Clip System: Clips designed for use in head-of-wall deflection conditions that provide a positive attachment of studs to tracks while allowing **[1-1/2-inch]** minimum vertical movement.
 - 2. Single Long-Leg Track System: ASTM C645 top track with 2-inch- (51-mm-) deep flanges in thickness not less than indicated for studs, installed with studs

- friction fit into top track and with continuous bridging located within 12 inches (305 mm) of the top of studs to provide lateral bracing.
3. Double-Track System: ASTM C645 top outer tracks, inside track with 2-inch- (51-mm-) deep flanges in thickness not less than indicated for studs and fastened to studs, and outer track sized to friction-fit over inner track.
 4. Deflection Track: Steel sheet top track manufactured to prevent cracking of finishes applied to interior partition framing resulting from deflection of structure above; in thickness not less than indicated for studs and in width to accommodate depth of studs.
- D. Firestop Tracks: Top track manufactured to allow partition heads to expand and contract with movement of structure while maintaining continuity of fire-resistance-rated assembly indicated; in thickness not less than indicated for studs and in width to accommodate depth of studs.
- E. Flat Strap and Backing Plate: Steel sheet for blocking and bracing in length and width indicated.
1. Minimum Base-Steel Thickness: **As indicated on Drawings.**
- F. Cold-Rolled Channel Bridging: Steel, 0.0538-inch (1.367-mm) minimum base-steel thickness, with minimum 1/2-inch- (13-mm-) wide flanges.
1. Depth: **1-1/2 inches (38 mm).**
 2. Clip Angle: Not less than 1-1/2 by 1-1/2 inches (38 by 38 mm), 0.068-inch- (1.72-mm-) thick, galvanized steel.
- G. Hat-Shaped, Rigid Furring Channels: ASTM C645.
1. Minimum Base-Steel Thickness: **[As indicated on Drawings]**.
 2. Depth: **As indicated on Drawings** or 7/8".
- H. Resilient Furring Channels: 1/2-inch- (13-mm-) deep, steel sheet members designed to reduce sound transmission.
1. Configuration: **hat shaped.**
- I. Cold-Rolled Furring Channels: 0.053-inch (1.34-mm) uncoated-steel thickness, with minimum 1/2-inch- (13-mm-) wide flanges.
1. Depth: **[As indicated on Drawings] [3/4 inch (19 mm)] <Insert depth>.**
 2. Furring Brackets: Adjustable, corrugated-edge-type steel sheet with minimum uncoated-steel thickness of 0.0329 inch (0.8 mm).
 3. Tie Wire: ASTM A641/A641M, Class 1 zinc coating, soft temper, 0.062-inch- (1.59-mm-) diameter wire, or double strand of 0.048-inch- (1.21-mm-) diameter wire.

2.3 SUSPENSION SYSTEMS

- A. Tie Wire: ASTM A641/A641M, Class 1 zinc coating, soft temper, 0.062-inch- (1.59-mm-) diameter wire, or double strand of 0.048-inch- (1.21-mm-) diameter wire.

B. Hanger Attachments to Concrete:

1. Post-Installed Anchors: Fastener systems with an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES [AC01] [AC193] [AC58] [or] [AC308] as appropriate for the substrate.
 - a. Uses: Securing hangers to structure.
 - b. Type: **expansion anchor**.
 - c. Material for Interior Locations: Carbon-steel components zinc-plated to comply with ASTM B633 or ASTM F1941 (ASTM F1941M), Class Fe/Zn 5, unless otherwise indicated.
 - d. Material for Exterior or Interior Locations and Where Stainless Steel Is Indicated: Alloy [Group 1 (A1)] [Group 2 (A4)] stainless-steel bolts, ASTM F593 (ASTM F738M), and nuts, ASTM F594 (ASTM F836M).
2. Power-Actuated Anchors: Fastener systems with an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC70.

C. Wire Hangers: ASTM A641/A641M, Class 1 zinc coating, soft temper, 0.16 inch (4.12 mm) in diameter.

D. Flat Hangers: **1 by 3/16 inch (25 by 5 mm) by length indicated.**

E. Carrying Channels (Main Runners): Cold-rolled, commercial-steel sheet with a base-steel thickness of 0.0538 inch (1.367 mm) and minimum 1/2-inch- (13-mm-) wide flanges.

1. Depth: **As indicated on Drawings.**

F. Furring Channels (Furring Members):

1. Cold-Rolled Channels: 0.0538-inch (1.367-mm) uncoated-steel thickness, with minimum 1/2-inch- (13-mm-) wide flanges, 3/4 inch (19 mm) deep.
2. Steel Studs and Tracks: ASTM C645.
 - a. Minimum Base-Steel Thickness: **0.0179 inch (0.455 mm).**
 - b. Depth: **1-5/8 inches .**
3. Embossed, High-Strength Steel Studs and Tracks: ASTM C645.
 - a. Minimum Base-Steel Thickness: **0.0147 inch (0.373 mm).**
 - b. Depth: **2-1/2 inches (64 mm)] [3-5/8 inches (92 mm)].**
4. Hat-Shaped, Rigid Furring Channels: ASTM C645, 7/8 inch (22 mm) deep.
 - a. Minimum Base-Steel Thickness: **0.0179 inch (0.455 mm).**
5. Resilient Furring Channels: 1/2-inch- (13-mm-) deep members designed to reduce sound transmission.

a. Configuration: **hat shaped**.

- G. Grid Suspension System for Gypsum Board Ceilings: ASTM C645, direct-hung system composed of main beams and cross-furring members that interlock.

1.

2.4 AUXILIARY MATERIALS

- A. General: Provide auxiliary materials that comply with referenced installation standards.

1. Fasteners for Steel Framing: Of type, material, size, corrosion resistance, holding power, and other properties required to fasten steel members to substrates.

- B. Isolation Strip at Exterior Walls: Provide[**one of**] the following:

1. Asphalt-Saturated Organic Felt: ASTM D226/D226M, Type I (No. 15 asphalt felt), nonperforated.
2. Foam Gasket: Adhesive-backed, closed-cell vinyl foam strips that allow fastener penetration without foam displacement, 1/8 inch (3.2 mm) thick, in width to suit steel stud size.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and substrates, with Installer present, and including welded hollow-metal frames, cast-in anchors, and structural framing, for compliance with requirements and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Suspended Assemblies: Coordinate installation of suspension systems with installation of overhead structure to ensure that inserts and other provisions for anchorages to building structure have been installed to receive hangers at spacing required to support the Work and that hangers will develop their full strength.
1. Furnish concrete inserts and other devices indicated to other trades for installation in advance of time needed for coordination and construction.
- B. Coordination with Sprayed Fire-Resistive Materials:
1. Before sprayed fire-resistive materials are applied, attach offset anchor plates or ceiling tracks to surfaces indicated to receive sprayed fire-resistive materials.

- Where offset anchor plates are required, provide continuous plates fastened to building structure not more than 24 inches (610 mm) o.c.
2. After sprayed fire-resistive materials are applied, remove them only to extent necessary for installation of non-load-bearing steel framing. Do not reduce thickness of fire-resistive materials below that are required for fire-resistance ratings indicated. Protect adjacent fire-resistive materials from damage.

3.3 INSTALLATION, GENERAL

- A. Installation Standard: ASTM C754.
 1. Gypsum Board Assemblies: Also comply with requirements in ASTM C840 that apply to framing installation.
- B. Install framing and accessories plumb, square, and true to line, with connections securely fastened.
- C. Install supplementary framing, and blocking to support fixtures, equipment services, heavy trim, grab bars, toilet accessories, furnishings, or similar construction.
- D. Install bracing at terminations in assemblies.
- E. Do not bridge building control and expansion joints with non-load-bearing steel framing members. Frame both sides of joints independently.
 1. Door Openings: Screw vertical studs at jambs to jamb anchor clips on door frames; install track section (for cripple studs) at head and secure to jamb studs.
 - a. Install two studs at each jamb unless otherwise indicated.
 - b. Install cripple studs at head adjacent to each jamb stud, with a minimum 1/2-inch (13-mm) clearance from jamb stud to allow for installation of control joint in finished assembly.
 - c. Extend jamb studs through suspended ceilings and attach to underside of overhead structure.
 2. Other Framed Openings: Frame openings other than door openings the same as required for door openings unless otherwise indicated. Install framing below sills of openings to match framing required above door heads.
 3. Fire-Resistance-Rated Partitions: Install framing to comply with fire-resistance-rated assembly indicated and support closures and to make partitions continuous from floor to underside of solid structure.
 - a. Firestop Track: Where indicated, install to maintain continuity of fire-resistance-rated assembly indicated.
 4. Sound-Rated Partitions: Install framing to comply with sound-rated assembly indicated.
 5. Curved Partitions:
 - a. Bend track to uniform curve and locate straight lengths so they are tangent to arcs.

- b. Begin and end each arc with a stud, and space intermediate studs equally along arcs. On straight lengths of no fewer than two studs at ends of arcs, place studs 6 inches (150 mm) o.c.

F. Direct Furring:

1. Screw to wood framing.
2. Attach to concrete or masonry with stub nails, screws designed for masonry attachment, or powder-driven fasteners spaced 24 inches (610 mm) o.c.

G. Z-Shaped Furring Members:

1. Erect insulation, specified in Section 072100 "Thermal Insulation," vertically and hold in place with Z-shaped furring members spaced **[24 inches (610 mm)]** o.c.
2. Except at exterior corners, securely attach narrow flanges of furring members to wall with concrete stub nails, screws designed for masonry attachment, or powder-driven fasteners spaced 24 inches (610 mm) o.c.
3. At exterior corners, attach wide flange of furring members to wall with short flange extending beyond corner; on adjacent wall surface, screw-attach short flange of furring channel to web of attached channel. At interior corners, space second member no more than 12 inches (305 mm) from corner and cut insulation to fit.

- H. Installation Tolerance: Install each framing member so fastening surfaces vary not more than 1/8 inch (3 mm) from the plane formed by faces of adjacent framing.

3.4 INSTALLING CEILING SUSPENSION SYSTEMS

- A. Install suspension system components according to spacings indicated, but not greater than spacings required by referenced installation standards for assembly types.

1. Hangers: **48 inches (1219 mm)** o.c.
2. Carrying Channels (Main Runners): **48 inches (1219 mm)** o.c.
3. Furring Channels (Furring Members): **16 inches (406 mm)** o.c.

- B. Isolate suspension systems from building structure where they abut or are penetrated by building structure to prevent transfer of loading imposed by structural movement.

- C. Suspend hangers from building structure as follows:

1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structural or suspension system.
 - a. Splay hangers only where required to miss obstructions and offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.
2. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with locations of hangers required to support

standard suspension system members, install supplemental suspension members and hangers in the form of trapezes or equivalent devices.

- a. Size supplemental suspension members and hangers to support ceiling loads within **performance limits established by referenced installation standards**.
3. Wire Hangers: Secure by looping and wire tying, either directly to structures or to inserts, eye screws, or other devices and fasteners that are secure and appropriate for substrate, and in a manner that will not cause hangers to deteriorate or otherwise fail.
4. Flat Hangers: Secure to structure, including intermediate framing members, by attaching to inserts, eye screws, or other devices and fasteners that are secure and appropriate for structure and hanger, and in a manner that will not cause hangers to deteriorate or otherwise fail.
5. Do not attach hangers to steel roof deck.
6. Do not attach hangers to permanent metal forms. Furnish cast-in-place hanger inserts that extend through forms.
7. Do not attach hangers to rolled-in hanger tabs of composite steel floor deck.
8. Do not connect or suspend steel framing from ducts, pipes, or conduit.
- D. Fire-Resistance-Rated Assemblies: Wire tie furring channels to supports.
- E. Seismic Bracing: Sway-brace suspension systems **with hangers used for support**.
- F. Grid Suspension Systems: Attach perimeter wall track or angle where grid suspension systems meet vertical surfaces. Mechanically join main beam and cross-furring members to each other and butt-cut to fit into wall track.
- G. Installation Tolerances: Install suspension systems that are level to within [**1/8 inch in 12 feet (3 mm in 3.6 m)**] measured lengthwise on each member that will receive finishes and transversely between parallel members that will receive finishes.

END OF SECTION 092216

SECTION 09 2900 - GYPSUM BOARD

PART 1 - GENERAL

1.1 SUMMARY:

- A. Related work:
 - 1. Rough carpentry.
 - 2. Finish carpentry and millwork.
 - 3. Tiling and stone work.
 - 4. Acoustical ceilings.
 - 5. Painting and coating.
 - 6. Wall coverings.
 - 7. Mechanical.
 - 8. Electrical.

1.2 ACTION SUBMITTALS:

- A. Product data: Indicate product description, including compliance with specified requirements and installation requirements. Include specific requirements for fire-rated and acoustically rated partitions and ceiling assemblies. Mark manufacturer's brochures to include only those products proposed for use. Include complete details of shaftwall system. Include details for supplementary fire protection at penetrations and locations of acoustical sealant.

1.3 INFORMATIONAL SUBMITTALS:

- A. Evaluation Reports: For firestop tracks, from ICC-ES.
- B. Structural design calculations: Submit for Architect's information only. Indicate compliance with specified design criteria. Calculations shall bear the seal of a professional engineer licensed in the State of Texas.

1.4 QUALITY ASSURANCE:

- A. Applicable standards; standards of the following:
 - 1. American National Standards Institute (ANSI).
 - 2. ASTM International (ASTM) as referenced herein.
 - 3. Association of the Wall and Ceiling Industries - International (AWCI).
 - 4. Ceilings and Interior Systems Construction Association (CISCA).
 - 5. Gypsum Association (GA).
 - 6. Steel Stud Manufacturers Association (SSMA).
 - 7. Underwriters Laboratories, Inc. (UL).
 - 8. Intertek Testing Services/Warnock Hersey, Inc. (WHI).
 - 9. "Recommended Specification: Levels of Gypsum Board Finish" as published jointly by the Gypsum Association, AWCI, CISCA and PDCA.
 - 10. Painting and Decorating Contractors of America (PDCA).
- B. Design criteria:
 - 1. Sound rating: Construct designated partitions in accord with manufacturer's product data, as submitted, for obtaining Sound Transmission Class (STC) ratings as indicated on the drawings, in accord with ASTM E90-09.
 - 2. Fire-resistance: Comply with fire-resistance designs indicated on the drawings. Use only manufacturers and types of materials as required by indicated designs. Designs with tests by other than Testing Agency listed may be submitted for Architect's acceptance, subject to prior acceptance by governing authorities.

1.5 DELIVERY, STORAGE AND HANDLING:

- A. Delivery: Deliver materials in original packages, containers or bundles bearing brand name, applicable standard designation and name of manufacturer or supplier.

- B. Storage:
 - 1. Stack gypsum board inside building under roof, off floor on pallets or similar platforms providing continuous support for gypsum board and to prevent sagging. Stack gypsum board flat and so that long lengths are not over short lengths.
 - 2. Protect gypsum board from direct exposure to rain, snow, sunlight or other excessive weather conditions.
 - 3. Protect ready-mixed adhesives and joint compounds against freezing, exposure to extreme heat and direct sunlight at all times.
 - 4. Do not overload floor systems.

1.6 PROJECT/SITE CONDITIONS:

- A. Do not install gypsum board until installation areas are enclosed.
- B. Environmental limitations: Comply with ASTM C840-11 requirements and gypsum board manufacturer's written recommendations, whichever are more stringent.
 - 1. During mechanical application of gypsum board, maintain room temperature at not less than 40 degree F.
 - 2. During adhesive application of gypsum board, joint treatment, and decoration, maintain room temperature not less than 50 degrees F for 48 hours prior to application and continuously thereafter until completely dry and until permanent heating system is in operation or building is occupied.
 - 3. When temporary heat source is used, temperature shall not exceed 95 degree F in any given room or area.
- C. Do not install panels that are wet, those that are moisture damaged, and those that are mold damaged.
 - 1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, or irregular shape.
 - 2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.
- D. Ventilation: Comply with ASTM C840-11 requirements and gypsum board manufacturer's written recommendations, whichever are more stringent.
 - 1. Provide ventilation during and following adhesive and joint treatment applications, and drying and curing periods.
 - 2. Use temporary air circulators in enclosed areas lacking natural ventilation.
 - 3. Under slow drying conditions, allow additional drying time between coats of joint treatment.
 - 4. Protect installed materials from drafts during hot, dry weather.
- E. When recommendations of manufacturer's product data exceed the above, comply with requirements of manufacturer's product data.

PART 2 - PRODUCTS

2.1 FRAMING MEMBERS:

- A. Gypsum board studs: Meeting requirements of ASTM C645-14; channel type, roll-formed from hot dip galvanized steel complying with ASTM A1003-13 and with ASTM A653-11a, G40 minimum.
 - 1. Stud size: As indicated on drawings, except minimum 3-5/8" depth where partition is indicated to receive tile and stone cladding finish.
 - 2. Stud gauge: As required by manufacturer's product data for heights and conditions of use, with maximum allowable deflections as follows:
 - a. Vertical shafts, excluding those with tile finishes:
 - 1) Non-structural studs: Minimum L/240 at 10 psf in accord with ASTM C645-13.
 - 2) Structural studs: Minimum L/240 at 20 psf in accord with ASTM C955-11c.

- b. Partitions to receive tile and FRP finishes:
 - 1) Non-structural studs: Minimum L/360 at 10 psf using 20 ga. or heavier studs, in accord with ANSI A108.11 and ASTM C645-13.
 - 2) Structural studs: Minimum L/360 at 20 psf using 20 ga. or heavier studs, in accord with ANSI A108.11 and ASTM C955-11c.
 - c. Partitions to receive abuse-resistant/impact-resistant wallboard:
 - 1) Non-structural studs: Minimum L/360 at 10 psf using 20 ga. or heavier studs, in accord with ASTM C645-14.
 - 2) Structural studs: Minimum L/360 at 20 psf using 20 ga. or heavier studs, in accord with ASTM C955-17.
 - 3) Stud gauge shall comply with gypsum panel manufacturer's requirements for tested design thickness.
 - d. Other partitions: Meet code requirements.
 - 3. Shaft Walls: "C-H" studs, hot-dipped galvanized, gauges as required to suit various clear-span conditions.
 - 4. Comply with submitted design calculations.
- B. Floor and ceiling runners: Hot dip galvanized steel, 1" deep, minimum, by widths to receive studs, same gauge as studs.
- 1. Shaft Wall: Steel "J" runners, galvanized steel.
- C. Single Long-Leg Runner System: ASTM C645-14 top runner with 2" deep flanges in thickness not less than indicated for studs, installed with studs friction fit into top runner and with continuous bridging located within 12" of the top of studs to provide lateral bracing.
- D. Slip-Type Head Joints: Where indicated, provide one of the following in thickness not less than indicated for studs and in width to accommodate depth of studs:
- 1. Double-Runner System: ASTM C 645 top runners, inside runner with 2-inch- (51-mm-) deep flanges and fastened to studs, and outer runner sized to friction fit inside runner.
 - 2. Deflection Track: Steel sheet top runner manufactured to prevent cracking of finishes due to deflection of structure above.
 - a. Products: Subject to compliance with requirements, provide one of the following:
 - 1) Steel Network Inc. (The); VertiClip SLD Series.
 - 2) Superior Metal Trim; Superior Flex Track System (SFT).
- E. Firestop Tracks: Manufactured to allow partition heads to expand and contract with movement of the structure while maintaining continuity of fire-resistance-rated assembly indicated; in thickness not less than indicated for studs and in width to accommodate depth of studs.
- 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Fire Trak Corp.; Fire Trak System attached to studs with Fire Trak Posi Klip.
 - b. Grace Construction Products; FlameSafe FlowTrak System.
 - c. Metal-Lite, Inc.; The System.
- F. Flat Strap and Backing Plate: Steel sheet for blocking and bracing in length and width indicated.
- 1. Minimum Base-Metal Thickness: 0.0528 inch or as otherwise indicated on Drawings.
- G. Cold-Rolled Channel Bridging: Steel, 0.053-inch minimum base-metal thickness, with minimum 1/2-inch- (13-mm-) wide flanges.
- 1. Depth: 1-1/2 inches (38 mm) or as otherwise indicated on Drawings.
 - 2. Clip Angle: Not less than 1-1/2 by 1-1/2 inches 0.068-inch- thick, galvanized steel.
- H. Hat-Shaped, Rigid Furring Channels: ASTM C 645.
- 1. Minimum Base-Metal Thickness: 0.033 inch (0.84 mm) or as otherwise indicated on Drawings.
 - 2. Depth: As indicated on Drawings.

- I. Resilient Furring Channels: 1/2-inch deep, steel sheet members designed to reduce sound transmission.
 - 1. Configuration: Asymmetrical.

2.2 GYPSUM BOARD:

- A. Regular board: Meeting ASTM C1396-11, 5/8" thickness, tapered rounded edges.
- B. Fire-retardant board: Meeting ASTM C1396-11, Type X, 5/8" thickness, tapered rounded edges.
- C. Mold and moisture resistant board: Treated paper-faced gypsum board.
 - 1. Acceptable products:
 - a. American Gypsum, M-Bloc Type X Gypsum Board.
 - b. Georgia-Pacific, ToughRock Mold-Guard Board, and ToughRock Fireguard X Mold-Guard Gypsum Board.
 - c. National Gypsum, GoldBoond XP Gypsum Board and XP Fire-Shield Gypsum Board.
 - d. USG Corporation, USG Sheetrock Brand Mold Tough.
 - 2. Thickness: 5/8" thickness Type X Grade fire-rated board, tapered edges.
 - 3. Description: Mold and moisture resistant gypsum core encased in mold and moisture resistant facers, with tapered long edges. Panels shall comply with ASTM C1396-11.
 - 4. Mold resistance: Resistant to mold growth when tested in accord with ASTM D3273-12, score of 10 as rated according to ASTM D 3274-09(2013).
 - 5. Water absorption: Less than 5% of board weight when tested in accord with ASTM C473-12.
 - 6. Joint tape: As recommended by gypsum board manufacturer.
 - 7. Limitations: Do not use as a tile backer board.
- D. Interior ceiling board: Meeting ASTM C1396-11, 1/2" thickness, Regular Grade, tapered edges.
- E. Coreboard: Meeting ASTM C1396-11, 1" thickness, square edges, fire-retardant board.

2.3 CEMENTITIOUS BACKER BOARD:

- A. Cementitious backer board: Meeting ASTM C1396-11 and ANSI A118.9, minimum 7/16" thickness, water-resistant, non-combustible, fiber-reinforced cement boards, manufacturer's standard sizes.
- B. Cementitious backer boards to be installed as substrate behind FRP Panels and porcelain wall tiles.

2.4 GYPSUM SHAFTWALL SYSTEM:

- A. Acceptable products; subject to compliance with specified requirements:
 - 1. American Gypsum, M-Bloc Shaft Liner.
 - 2. G-P Gypsum Products, DensGlass Shaftliner.
 - 3. National Gypsum Co., eXP Extended Exposure Shaftliner.
 - 4. U. S. Gypsum Co., Sheetrock Glass-Mat Liner Panels.
- B. Materials: Moisture- and mold-resistant, noncombustible, Type X gypsum shaftliner coreboard coated with glass mat facings, metal framing members, and fiber-reinforced gypsum board with fiberglass mat face on unexposed side and paper face on exposed side.
- C. Fire-resistive rating: In accord with fire-rated assembly design indicated.
- D. Shaftwall framing members shall be of size and spacing required by manufacturer's product data to withstand a pressure load of 7.5 psf with a maximum deflection of L/120.

2.5 ABUSE-RESISTANT, IMPACT-RESISTANT BOARD:

- A. Acceptable products:
1. American Gypsum, M-Bloc Impact Resistant Type X Gypsum Board.
 2. Georgia-Pacific: ToughRock Fireguard X Mold-Guard Abuse-Resistant Gypsum Board.
 3. National Gypsum Co., Gold Bond Hi-Impact XP Gypsum Board.
 4. USG Corporation, USG Sheetrock Board Mold Tough VHI.
- B. Characteristics:
1. Limitations: Do not use as a base for wall tile installation. Do not use in wet areas.
 2. Description: Fiber-reinforced or glass mesh enhanced core gypsum board meeting ASTM C1396-17; minimum Type C or Type X fire-resistance rated.
 3. Thickness: 5/8".
 4. Abrasion resistance: Surface abrasion depth shall be maximum 0.059" when tested in accord with ASTM D4977-03(2013); or achieve minimum Level 2 abrasion resistance when tested in accord with ASTM C1629-15.
 5. Surface indentation: Surface indentation shall be maximum 0.100" when tested in accord with ASTM D5420-16; or achieve minimum Level 2 indentation resistance when tested in accord with ASTM C1629-15.
 6. Soft body impact: Minimum 300 ft.-lbs. to failure for single drop when tested in accord with ASTM E695-03(2015); or achieve minimum Level 3 soft body impact resistance when tested in accord with ASTM C1629-15.
 7. Hard body impact: Minimum 150 ft.-lbs. to failure and achieve minimum Level 3 hard body impact resistance when tested in accord with ASTM C1629-15.
 8. Fire resistance: Noncombustible, minimum Type X, meeting UL minimum one-hour fire resistance, meeting ASTM E136-16a and ASTM E84-17; flamespread rating of 15 maximum and smoke developed rating of 0.
 9. Mold resistance: Resistant to mold growth when tested in accord with ASTM D3273-16, score of 10.

2.6 SOUND CONTROL MATERIALS:

- A. Contractor's option: Based on sound ratings and fire-resistance ratings required for assemblies, Contractor may select glass fiber or mineral wool sound attenuation materials as follows:
1. Glass fiber sound attenuation batts:
 - a. Acceptable manufacturers:
 - 1) CertainTeed Corp.
 - 2) Knauf Insulation.
 - 3) Johns Manville Corp.
 - 4) Owens-Corning Corp.
 - b. Characteristics:
 - 1) Type: Unfaced fiberglass batts for friction fit between studs, complying with ASTM C665-12, Type 1.
 - 2) Surface burning characteristics: Maximum 25 flame spread and 50 smoke development when tested in accord with ASTM E84-12c.
 - 3) Assembly STC: As indicated on drawings.
 - 4) Thickness: As indicated on drawings.
 2. Mineral wool sound attenuation blankets:
 - a. Acceptable manufacturers:
 - 1) Basis of design; ROCKWOOL SAFE'n'SOUND® is a mineral wool batt insulation for interior partitions.
 - 2) IIG, MinWool, LLC, MinWool Sound Attenuation Fire Batt.
 - 3) Owens-Corning Corp., Sound Attenuation Fire Batt.
 - 4) U. S. Gypsum Co., Thermafiber SAFB (Sound Attenuation Fire Blankets). Owens-Corning Corp.
 - b. Characteristics:
 - 1) Type: Paperless, semi-rigid mineral wool fiber blanket complying with ASTM C665-12, Type 1.

- 2) Density: Maximum 4.0 pcf for 1" thickness, and maximum 2.5 pcf. for greater thicknesses.
 - 3) Surface burning characteristics: Maximum 15 flame spread and 5 smoke development when tested in accord with ASTM E84-12c.
 - 4) Assembly STC: As indicated on drawings.
 - 5) Thickness: As indicated on drawings.
- B. Acoustical tape: Closed cell polyvinyl chloride foam tape, 1/4" thickness by 1" wide.
- C. Acoustical Joint Sealant: Manufacturer's standard non-sag, paintable, non-staining latex sealant complying with ASTM C834-10. Product effectively reduces airborne sound transmission through perimeter joints and openings in building construction as demonstrated by testing representative assemblies according to ASTM E90-09.
1. Products: Subject to compliance with requirements, provide one of the following available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Accumetric LLC; BOSS 824 Acoustical Sound Sealant.
 - b. Grabber Construction Products; Acoustical Sealant GSC.
 - c. Pecora Corporation; AC-20 FTR.
 - d. Specified Technologies, Inc.; Smoke N Sound Acoustical Sealant.
 - e. USG Corporation; SHEETROCK Acoustical Sealant.
 2. Acoustical joint sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- D. Acoustic Partition Closure: EMSEAL Joint Systems, Ltd., QuietJoint; open-cell foam infused with a mass-loading, fire-retardant impregnation.
1. Non-invasively-anchored, high-STC/OITC, sound attenuating, fire-resistant, and thermally insulating mass-loaded partition closure for sealing construction-created voids and gaps.
 2. Typical locations include, but are not limited to the following: acoustic partition barriers, end of partition to window (SHG 3-sided coating), end of partition to mullion (SHH 2-sided coating), end of partition to wall (SHH), and head of wall (SHH).
 3. Silicone external color facing: Factory-applied to the foam. Silicone coating to be available in a range of not less than 26 standard colors for coordination with typical building materials.
 4. Select the sealant system model appropriate to the design requirements at each gap location that meets the project condition.
 5. Supply in full-storey, 10'-0" lengths, and ship in loosely laid coils inside cardboard boxes.
 6. Size material approximately 10% larger than the field-measured joint width. Supply standard offered width and depth of seal to suit field verified conditions as shown on drawings.

2.7 FASTENERS:

- A. Fasteners for metal framing, corrosion-resistant:
1. For fastening framing members to concrete and masonry surfaces: Fasteners shall be beaded drive pins or threaded studs driven by powder actuated tools. Fasteners shall resist design loads in accord with requirements of ASTM E1190-11.
 2. For fastening to metal decking and for fastening framing members together: Type S, pan head screws, in sizes recommended by gypsum board manufacturer for applications indicated.
 3. Provide slotted, stand-off washers for slip joint attachments.
- B. Screws for gypsum board and accessory application: Meeting ASTM C1002-07, corrosion-resistant.
1. For application of single layer or base layer of gypsum board to metal framing: 1", Type S, bugle head.

2. For application of face layer of gypsum board to metal framing in double layer construction: 1-5/8", Type S, bugle head.
 3. For gypsum board to gypsum board application: 1-1/2", Type G, buglehead.
- C. Screws for tile backer board application: Corrosion resistant sheet metal screws with head diameter providing 125 lb. fastener pull-through and pull-out resistance. Screw length shall provide 1/4" minimum thread engagement.

2.8 JOINT MATERIALS AND ADHESIVES:

- A. Standard gypsum board products:
1. Joint tape: Meeting ASTM C475-12, perforated paper type.
 2. Joint compound: Meeting ASTM C475-12, ready-mixed tape embedment and topping compounds, vinyl-based.
- B. Mold and moisture resistant paper faced gypsum board: Joint tape and joint compound shall be in accord with recommendations of board manufacturer's product data.
- C. Joint treatment for cementitious backer board: Use same materials, as specified in Section 09 3000 - Tiling, for setting tile.
- D. Joint tape for glass mat-faced tile backer board: Fiberglass tape, as herein specified.
- E. Joint tape and joint compound for abuse and impact resistant gypsum board: As recommended by board manufacturer's product data.
- F. Laminating adhesive: Adhesive or joint compound recommended by gypsum board manufacturer's product data for directly adhering gypsum board to continuous substrate.
1. Laminating adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.9 SUSPENDED GYPSUM BOARD FURRING SYSTEM:

- A. Acceptable manufacturers: Armstrong World Industries, Inc.
- B. Characteristics:
1. Structural classification: Meeting ASTM C635-12, Heavy Duty.
 2. Components: Fabricated from minimum 0.018" base metal thickness, galvanized, cold-rolled steel; double web design.
 3. Suspension wires: Not to exceed 18 ga. Do not use metal studs at full ceiling areas.

2.10 TRIM AND ACCESSORIES:

- A. PVC Trim Accessories:
1. Basis of design; Trim-Tex, Inc. with recycled content at least 50 percent.
 2. Interior Trim: ASTM C1047.
 3. Material: Rigid PVC products meeting ASTM D3678-97 Class 2, D1784-03, C1047-99 and achieve a Class A rating for flame spread and smoke developed when tested under ASTM E84-14.
 4. Shapes: Including, but not limited to, following:
 - a. Standard Cornerbeads; 1-3/4" mud flange.
 - b. Bullnose bead; 7/8" and 1" mud flange.
 - c. LC-Bead: J-shaped; exposed long flange receives joint compound.
 - d. L-Bead: L-shaped; exposed long flange receives joint compound.
 - e. U-Bead: J-shaped; exposed short flange does not receive joint compound.
 - f. Expansion (control) joint.
- B. Ceiling Mounted Deflection Bead: Trim-Tex, Model #9240 Ceiling Mounted Deflection Bead Set Drywall Down.

1. Description: Trim-Tex Ceiling Mounted Deflection Beads; rigid PVC products meeting ASTM D3678-97 Class 2, D1784-03, C1047-99 and achieve a Class A rating for flame spread and smoke developed when tested under ASTM E84-14 designed to mount to the roof deck and will slide up and down the wall during deflection to prevent cracks.
 - a. Advantages: The 1" leg hangs down the wall to cover up to a 3/4" gap, left between the drywall and the floor deck. Since it is only attached to the deck, the ceiling Mounted Deflection Bead slides up and down the wall. It leaves a sharp crisp shadow line along the length of the wall. Comes with a full 5/16" tear-off strip that acts as a guide for the taping knife as well as a protective masking for taping and mudding. Made from rustproof, dent resistant PVC to reduce jobsite and handling damage. Does not contain cellulose, a potential food source for mold.
2. Taping Joint Compound: Trim-Tex Mud-Max (#850) to the setting and base coat of compound. Embed the deflection bead into the compound and press into place with a taping knife.
 - a. Coat the bead as needed.
3. Finishing: Once mudding is complete, remove tear-off leg for a clean, sharp look. Always use a high quality paint.

2.11 ACCESSORIES:

- A. Furring channels: Minimum 25 ga. galvanized steel, 7/8" deep by 1-3/8" face width.
- B. "Z" furring channels: Minimum 25 ga. galvanized steel to receive 1 insulation.
- C. Cold-rolled channels: Minimum 16 ga. steel, hot dip galvanized or black asphaltum-painted, as follows:
 1. 3/4" depth: 300 lbs./mlf, for use as horizontal stiffeners, bracing and cross furring.
 2. 1-1/2" depth: 475 lbs./mlf, for use as main ceiling runners.
- D. Furring channel clips: Manufacturer's standard type for attachment of furring channels to cold-rolled runner channels.
- E. Resilient channel: Galvanized steel, manufacturer's standard type.
- F. Furring brackets: Minimum 20 ga. galvanized steel, for attaching 3/4" furring channels to masonry walls.
- G. Ceiling hangers:
 1. Wire: Minimum eight ga. galvanized annealed steel wire.
 2. Rod: 1/4" diameter, rust-resistant painted, threaded cold-drawn mild steel.
- H. Tie wire: Minimum 18 ga. galvanized, annealed steel wire.
- I. Special trim shapes:
 1. Acceptable manufacturers; subject to compliance with specified requirements:
 - a. Fry Reglet Corp.
 - b. Gordon, Inc.
 - c. Pittcon Industries, Inc.
 2. Characteristics:
 - a. Material: Manufacturer's standard aluminum alloy.
 - b. Finish: Painted finish, color selected by Architect.
 - c. Shapes: As indicated on the drawings.
 3. Reveals:
 - a. R-1: CEMCO, 093 Control Joint.
 - b. R-2: CEMCO, 093 Control Joint.
 - c. R-3: Fry Reglet, DRMF-50-25 Reveal Molding, 1/2-inch x 1/4-inch, at gypsum board to exposed structure connection.

PART 3 - EXECUTION

3.1 FRAMING AND FURRING INSTALLATION:

- A. Except where more stringent requirements are specified, install framing and furring in accord with ASTM C754-11, Gypsum Association requirements and manufacturer's product data.
- B. Runners:
 - 1. Attach runner tracks at floor and underside of structural deck with specified fasteners. Provide slip joint attachments to meet deflection criteria and manufacturer's calculations at the following locations:
 - a. Tall partitions.
 - b. Full-height, floor-to-floor or floor-to-deck partitions.
 - c. All partitions subject to deflection.
 - 2. Where partitions are indicated to stop at finish ceiling, attach to ceiling suspension system using 1/8" toggle bolts or sheet metal screws spaced at 1'-4" o. c., maximum, where partition aligns with ceiling grid. Where partition does not align with grid, attach at each intersection with grid.
- C. Studs:
 - 1. Position full length studs vertically, engaging floor and ceiling runners.
 - a. Space studs as indicated on drawings.
 - b. Space studs not to exceed 1'-4" o. c. for partitions to receive tile, FRP panels and stone finish(es).
 - 2. Provide double studs at interior and exterior corners, expansion joints, partition termination and adjacent to door and borrowed lite openings in partitions. Locate next stud not more than 6" from double studs.
 - 3. Secure abutting and intersecting walls with fasteners through stud flanges.
 - 4. For horizontal reinforcement at door and borrowed lite frames, install cut-to-length runner sections with slit flanges secured to studs.
 - 5. Install acoustical tape on metal studs which abut other studs or dissimilar surfaces in walls to receive sound attenuation blankets.
 - 6. Do not use metal studs at full ceiling areas.
- D. Furring:
 - 1. Attach to masonry and concrete substrate with fasteners spaced at 2'-0" o. c. on alternating furring channel flange.
 - 2. Position channels vertically, spaced at 1'-4" o. c., maximum.
- E. At locations of stair handrails attached to metal-framed gypsum board partitions, provide minimum 20 ga. steel plate, set at handrail height and rise, for handrail bracket attachment. Attach to metal framing, full length of handrail.

3.2 CEILING SUSPENSION SYSTEMS:

- A. Provide complete suspension system, including hangers, main runner channel, furring channels and attachments. Sizes, locations and spacings shall comply with ASTM C754-11 and fire-rated design assemblies indicated.
- B. Secure to structural framing members by attaching to metal clips designed for the type of member involved or, where possible, by looping and wire-tying directly to member.
- C. Secure to concrete by wire-tying to cast-in-place hanger wires or hanger inserts, installed prior to placing of concrete, or by powder-actuated fasteners which develop full strength of hanger. Coordinate placement of wire hangers or inserts with concrete work.
- D. Secure to metal decking by wire-tying or hanger clips or slots. If slots are provided for metal decking which also acts as permanent formwork, install hangers before concrete is placed.

- E. Hangers:
 - 1. Space hangers at 4'-0" o. c., maximum, in each direction.
 - 2. Wrap wire a minimum of three times horizontally, turning ends upwards.
- F. Provide extra hangers within 6" of ends of main runners and to support light fixtures, ceiling diffusers and grilles, access panels and other items resting in or on ceilings. At control joints, provide extra hangers to support discontinuous runners.
- G. Locate hangers plumb in relation to main runners and to avoid contact with insulation covering ducts and pipes. Do not pass hangers through ducts. Alter spacing of hangers or splay hangers to avoid ducts and other obstructions, but do not exceed maximum allowable ceiling areas to be supported by each hanger. Offset horizontal forces of splayed hangers by countersplaying or bracing.
- H. Install cold-rolled channels at 4'-0" o. c., maximum, running perpendicular to structure. Install furring channels perpendicular to cold-rolled channels.
- I. Locate main runners within 6" of parallel walls to support ends of cross-furring.
- J. Locate furring channels perpendicular to main runners and not more than 2" from parallel walls. Attach to main runners at each intersection with a double strand of 16 ga. wire.
- K. Do not abut runners or furring into masonry or concrete construction; allow not less than 1" clearance between such construction and ends of runners or furring.
- L. Splice main runners and furring channels by overlapping, with flanges of channels interlocked, and wire-tie each end of splice with not less than double strand of 16 ga. wire. Overlap not less than 1'-0" for main runner splices and not less than 8" for furring channels.
- M. Provide additional ceiling framing as required to frame openings. Coordinate support framing with the work of other trades.
- N. At control joints, provide discontinuous lap in main runners and accessories occurring over joints. Do not bridge joints with cross-furring where joints run perpendicular to furring. Where joints run parallel to furring, provide furring to support each side of joint.

3.3 SUSPENDED GYPSUM BOARD FURRING SYSTEM INSTALLATION:

- A. Install suspension system in accord with ASTM C754-11 and fire-rated design assemblies indicated.
- B. Hangers:
 - 1. Space hangers at 4'-0" o. c., maximum, in each direction. Secure to building structure.
 - 2. Install additional hangers at ends of each suspension member and at each corner of lighting fixtures.
 - 3. Splay wires no more than 5" in 4'-0" vertical drop.
 - 4. Wrap wire minimum of three times horizontally, turning ends upward.
- C. Space main tees at 4'-0" o. c., perpendicular to structure. Space cross tees at 2'-0" o. c., perpendicular to main tees to form 2'-0" by 4'-0" grid system.
- D. Level and square suspension system within specified tolerances.
- E. Where grid system exists in an unrestrained condition, brace back to building structure using hanger wire, main tee or carrying channel braces spaced at 4'-0" o. c., maximum.

3.4 GENERAL BOARD APPLICATION:

- A. Except where more stringent requirements are specified, install gypsum board in accord with ASTM C840-11, GA-216 and manufacturer's product data.
- B. Use gypsum board of maximum lengths to minimize end joints. Stagger end joints.
- C. Abut gypsum boards without forcing. Fit ends and edges of board. Do not place butt ends against tapered edges.
- D. Support ends and edges of gypsum board panels on framing or furring members, except for face layer of double layer work.
 - 1. Install gypsum board accessories in accord with gypsum board manufacturer's product data and as follows: Control joints: Install in walls and ceilings in accord with requirements of ASTM C840-11 and in specific locations approved by Architect for visual effect. Attach with staples to panel face. Where control joints occur in fire rated partitions, comply with code requirements and gypsum board manufacturer's product data.
 - 2. Corner bead: Install at external corners.
 - 3. Metal trim shapes: At exposed edge of gypsum board at door and window openings, at intersections with other materials and at intersection of walls with ceilings.
 - 4. Install corner beads and metal trim shapes to framing system with mechanical anchors.
 - 5. PVC top of wall deflection bead:
 - a. Include the PVC deflection bead at the top of wall conditions. This bead is in addition to fire and acoustic sealants at the head track.
 - b. Install PVC deflection bead in a slightly compressed fashion.
- E. Install acoustical sealant at sound-rated partitions:
 - 1. Seal partition perimeter with continuous 1/4" minimum round bead of acoustical sealant applied to each leg of runners, including those used at partition intersections with dissimilar wall construction.
 - 2. Install gypsum board with 1/8" perimeter relief compressing sealant to form permanent airtight seal.
 - 3. Where slip joint attachments are required at top of partition, fill resulting joint between drywall and adjacent structure with acoustical sealant to form permanent air tight seal.
 - 4. Apply acoustical sealant around cutouts such as at electrical boxes, plumbing penetrations, medicine cabinets, heating ducts and cold air returns to form permanent airtight seal. (Sealant shall not be used as a fire stopping material.)
- F. Acoustic partition closure installation:
 - 1. Consult manufacturer's installation instructions supplied with materials before proceeding.
 - 2. Being careful not to stretch it, lay out the material and cut it to the desired length.
 - 3. Position material over the joint opening and squeeze by hand to ease it into the joint. Position the material so as to ensure a uniform, flat, plane.
 - 4. The silicone coating will fold at its edges to absorb slight variations in substrates while maintaining a smooth appearance.
 - 5. Once in desired location, use a plastic putty knife to tuck the edges of the silicone against the substrates to remove any wrinkles.
 - 6. The internal backpressure of the material will mate it to the mullion, partition, glass or other joint faces. The material is to remain free of any metal components, i.e. fasteners, screws, bolts, extrusions, etc.
- G. Install sound attenuation blankets at locations indicated on drawings. Comply with manufacturer's product data for installation. Attach flanges of blanket to web of stud and not to face of stud receiving gypsum board.

- H. Shaftwall system: Install in accord with manufacturer's product data, except where more stringent requirements are specified.
 - 1. Provide supplementary fire protection at penetrations in accord with manufacturer's product data details.
 - 2. Provide additional reinforcement of shaft at openings and penetrations in system in accord with manufacturer's product data.
 - 3. Caulk perimeter of shaftwall system, including framing components and base gypsum board layer and penetrations, using shaftwall manufacturer's recommended sealant.
 - 4. Where components penetrate shaftwall system, caulk perimeter and provide additional fire protection in accord with manufacturer's product data.
- I. Install cementitious backer board for fiberglass reinforced plastic wall panels and tile panels; in accord with ANSI A108.11.
- J. For fire-rated and acoustically rated construction, comply with requirements of tested assemblies scheduled on the drawings.
- K. Continue required components of fire-rated and acoustically rated wall assembly to overhead structure. Apply joint tape and one coat of compound to gypsum board joints concealed from view in completed work.
- L. Seal openings and penetrations in fire-rated construction as specified in Section 07 8400 - Firestopping.
- M. Identification:
 - 1. Fire walls, fire barriers, fire partitions, smoke barriers and smoke partitions or any other wall required to have protected openings shall be effectively and permanently identified with signs or stenciling in a manner acceptable to the Authority having Jurisdiction.
 - 2. Such identification shall be above any decorative ceiling and in concealed spaces.
 - 3. Suggested wording for fire and smoke barriers: "____ HOUR FIRE AND SMOKE BARRIER – PROTECT ALL OPENINGS."
- N. Attach gypsum board to resilient channels with screws of length to not contact framing.
- O. Allowable tolerances in framed gypsum board construction.
 - 1. Position: $\pm 1/4$ " maximum variation from design position.
 - 2. Alignment: $1/8$ " in 8'-0"; $1/4$ " maximum in any continuous wall, line or surface.
 - 3. Surface plane: $1/8$ " in 12'-0"; $1/16$ " in 1'-0", maximum variation in true surface plane.
 - 4. Surface smoothness: No joint or fastener location, roughness or blemish discernible after application of finish when viewed at any angle from a distance of 5'-0" under occupancy lighting conditions, with surface preparation as specified in Section 09 9100 - Painting and Coating.
- P. Allowable tolerances in suspended gypsum board furring system ceilings:
 - 1. Deflection: Suspension system components, hangers and fastening devices supporting lighting fixtures, ceiling grilles and acoustical units shall have maximum deflection of $1/360$ of span when tested in accord with ASTM C635-12.
 - 2. Bow, camber and twist: Not exceeding tolerances established by ASTM C635-12.
 - 3. Variation from level in finished ceiling: $\pm 1/8$ " in 12'-0".
 - 4. Variation in plane of adjacent gypsum board panels prior to joint treatment: $1/16$ ".

3.5 DOUBLE LAYER APPLICATION:

- A. Base layer:
 - 1. Ceilings: Apply base layer with long dimension at right angle to framing. Terminate edges of gypsum board running parallel to framing on framing members.

2. Walls: Apply base layer vertically. Terminate edges of gypsum board running parallel to framing, furring on framing or furring members. Stagger vertical joints on opposite sides of partitions.
 3. Fastening: Attach gypsum board using fasteners specified, at spacings required by manufacturer's product data.
- B. Face layer:
1. Apply face layer at right angle to base layer with minimum 10" offset in parallel base and face layer joints.
 2. Fastening: Attach gypsum board using fasteners specified, at spacings required by manufacturer's product data.
 3. Sheet lamination:
 - a. Apply adhesive to entire back surface of face panel using laminating spreader or notched metal spreader blade.
 - b. Pre-cut and pre-fit face panels prior to mixing adhesive.
 - c. Provide temporary fasteners at 1'-4" o. c. Remove temporary fasteners after bond develops between layers. Dimple nail holes prior to applying joint treatment.
 - d. Provide temporary bracing at 1'-4" o. c., until bond develops between layers.
 - e. Provide permanent mechanical fasteners in accordance with manufacturer's printed recommendations for fire-rated assemblies.

3.6 JOINT TREATMENT:

- A. Finish Levels shall be in accord with the "Recommended Levels of Finish for Gypsum Board, Glass Mat and Fiber-Reinforced Gypsum panels", GA-214-2015, as published jointly by the Gypsum Association, AWCI, CISCA, DFC and PDCA.
- B. Finish Level 0; temporary construction: No taping, finishing, or accessories required.
- C. Finish Level 1; joint treatment in smoke barrier applications and areas not normally open to public view such as plenum areas above ceilings, attics, and other areas where the assembly would generally be concealed:
1. Joints and interior angles shall have tape embedded in joint compound.
 2. Excess joint compound, tool marks and ridges are acceptable.
 3. Accessories are optional unless specified or indicated in the contract documents.
- D. Finish Level 2; where board products are used as a substrate for tile, fiberglass reinforced plastic (FRP) wall panels and in storage, or other similar areas where surface appearance is not a concern.
1. Joints and interior angles shall have tape embedded in joint compound and wiped with a joint knife leaving a thin coating of joint compound over joints and interior angles. Joint compound applied over the body of the tape at the time of tape embedment shall be considered a separate coat of joint compound and shall satisfy the conditions of this level.
 2. Fastener heads and accessories shall be covered with one (1) coat of joint compound.
 3. Surface shall be free of excess joint compound. Tool marks and ridges are acceptable.
 4. Cementitious backer board for FRP and tiles:
 - a. Prefill joints and joints where boards abut other panels or surfaces with material used to set tiles and then embed tape and level joints.
 - b. Caulk or seal penetrations and abutments to dissimilar materials.
- E. Finish Level 3; appearance areas that are to receive heavy- or medium-texture finishes (spray or hand applied) before final painting is applied as the final decoration:
1. Joints and interior angles shall have tape embedded in joint compound and shall be immediately wiped with a joint knife leaving a thin coating of joint compound over all joints and interior angles. One (1) separate coat of joint compound shall be applied over all joints and interior angles.
 2. Fastener heads and accessories shall be covered with two (2) separate coats of joint compound.

3. Surface shall be smooth and free of tool marks and ridges.
 4. Jobsite mock-up(s) shall be used to determine acceptance of the finish within the building.
- F. Finish Level 4; Appearance areas where smooth wall designs are decorated with flat paints, light textures, non-continuous textures, or where wall coverings are to be applied:
1. Joints and interior angles shall have tape embedded in joint compound and shall be immediately wiped with a joint knife leaving a thin coating of joint compound over joints and interior angles.
 2. Apply two (2) separate coats of joint compound over flat joints and apply one (1) separate coat of joint compound over interior angles.
 3. Cover fastener heads and accessories with three (3) separate coats of joint compound.
 4. Surface shall be smooth and free of tool marks and ridges.
 5. Where glass mat and/or fiber-reinforced gypsum panels are installed, refer to the gypsum panel manufacturer's product data for specific finishing recommendations.
 6. Jobsite mock-up(s) shall be used to determine acceptance of the finish within the building.
- G. Finish Level 5; Appearance areas where smooth wall designs are decorated with non-flat paints (i.e., sheen/gloss) or other glossy decorative finishes, dark/deep tone paints are applied, or, critical lighting conditions occur.
1. Joints and interior angles shall have tape embedded in joint compound and shall be immediately wiped with a joint knife leaving a thin consistent coating of joint compound over joints and interior angles.
 2. Apply two (2) separate coats of joint compound over flat joints and apply one (1) separate coat of joint compound over interior angles.
 3. Cover fastener heads and accessories with three (3) separate coats of joint compound.
 4. Apply a thin skim coat of joint compound (as identified in GA 214-2015) or a material manufactured especially for this purpose to the entire surface.
 5. Surface shall be smooth and free of tool marks and ridges.
 6. Where glass mat and/or fiber-reinforced gypsum panels are installed, refer to the gypsum panel manufacturer's product data for specific finishing recommendations.
 7. Jobsite mock-up(s) shall be used to determine acceptance of the finish within the building.
- H. Fastener pop: Drive new fastener approximately 1-1/2" from popped fastener and repair to match gypsum board finish.
- I. Fill cracks with joint compound and sand smooth and flush.
- J. Dust surfaces and leave ready for decoration. Joint and fastener treatment shall be indistinguishable in finished work.
- K. Fastener pop: Drive new fastener approximately 1-1/2" from popped fastener and repair to match gypsum board finish.
- L. Fill cracks with joint compound and sand smooth and flush.
- M. Dust surfaces and leave ready for decoration. Joint and fastener treatment shall be indistinguishable in finished work.

END OF SECTION

SECTION 09 3000 - TILING

PART 1 - GENERAL

1.1 ACTION SUBMITTALS:

- A. Shop drawings: Submit for tile pattern work indicated. Indicate control and expansion joint locations. Include tile layout, setting bed thicknesses, joint widths, control and expansion joint sizes and sections.
- B. Product data: Submit manufacturer's printed product description and installation instructions for each type of tile and for use of manufactured mortars, grouts, adhesives, sealants, latex/polymer additives, crack isolation membrane and accessory products. Include mortar and grout proportioning and mixing instructions for latex/polymer additives.
- C. Samples; submit the following:
 - 1. 1'-0" by 1'-0" panel of each type and color tile selected, grouted as specified.
 - 2. Samples of each trim shape required.
 - 3. 1'-0" length of threshold.
 - 4. Samples of each accessory required.
 - 5. Submit samples of color sealant materials for Architect's approval.

1.2 INFORMATIONAL SUBMITTALS:

- A. Master grade certificates: Indicate that tile materials conform to ANSI A137.1. Certificates shall indicate grade, kind of tile, identification for tile packages and name and location of project. Tile manufacturer shall issue certificates at time of shipping.
- B. Certification: Submit written certification that crack isolation membrane is approved for use with specified mortars.

1.3 QUALITY ASSURANCE:

- A. Applicable standards:
 - 1. Standards of the following, as referenced herein:
 - a. American National Standards Institute (ANSI).
 - b. ASTM International (ASTM).
 - c. Marble Institute of America, Version VII (MIA).
 - 2. Tile Council of North America (TCNA), "Handbook for Ceramic, Glass, and Stone Tile Installation," 2018 Edition.
- B. For each type of setting material and grouting material specified, only one brand shall be used throughout project.
- C. Allowable tolerances: Plumb, level and true to line, meeting ANSI A108.02 as follows:
 - 1. For tile with all dimensions less than 15": Maximum 1/16" in 1'-0" and maximum 1/4" in 10'-0".
 - 2. For tile with any dimension greater than 15": Maximum 1/16" in 2'-0" and maximum 1/8" in 10'-0".

1.4 DELIVERY, STORAGE AND HANDLING:

- A. Deliver materials in original containers with labels legible and intact, identifying brand name and contents.
 - 1. Tile cartons shall be grade-sealed by manufacturer in accord with ANSI A137.1 and ANSI A137.2, with grade seals unbroken.
 - 2. Manufactured mortars, adhesives and grouts shall bear hallmarks certifying compliance with specified standards.

1.5 JOB CONDITIONS:

- A. Environmental requirements:
 - 1. For field-mixed mortar and grout, set and grout tile when ambient temperature is at least 50°F. and rising.
 - 2. For manufactured mortar, adhesive and grout, comply with minimum temperature recommendations of manufacturers.

1.6 MAINTENANCE:

- A. Extra materials:
 - 1. Provide not less than 3% of installed total of each type, size and color of tile specified and 3% of each type, size and color of accessory, for Owner's maintenance.
 - 2. Store tile and accessory units where indicated by Owner.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL:

- A. Factory blending: For tile exhibiting color variations within ranges, blend tile in factory and package so tile units taken from one package show same range in colors as those taken from other packages and match approved Samples.
- B. Mounting: For factory-mounted tile, provide back- or edge-mounted tile assemblies as standard with manufacturer unless otherwise indicated.
 - 1. Where tile is indicated for installation in wet areas, do not use back- or edge-mounted tile assemblies unless tile manufacturer specifies in writing that this type of mounting is suitable for installation indicated and has a record of successful in-service performance.
- C. Where tile is indicated for installation in wet areas, do not use back- or edge-mounted tile assemblies unless tile manufacturer specifies in writing that this type of mounting is suitable for installation indicated and has a record of successful in-service performance.
- D. Factory-applied temporary protective coating: Where indicated under tile type, protect exposed surfaces of tile against adherence of mortar and grout by pre-coating with continuous film of release agent as recommended by mortar and grout manufacturer or a hot-applied petroleum paraffin wax. Do not coat backs or sides of tile surfaces.
- E. ANSI Ceramic Tile Standard: Provide tile that complies with ANSI A137.1 for types, compositions, and other characteristics indicated.
 - 1. Provide tile complying with Standard grade requirements unless otherwise indicated.
- F. ANSI Standards for Tile Installation Materials: Provide materials complying with ANSI A108.02, ANSI standards referenced in other Part 2 articles, ANSI standards referenced by TCA installation methods specified in tile installation schedules, and other requirements specified.
- G. Provide products in this Section with low VOCs and emissions.

2.2 TILE:

- A. Basis of design; Dal-Tile, for each type of tile and is scheduled on the drawings. Tile of similar characteristics, as manufactured by other acceptable manufacturers, may be submitted for Architect's consideration.
- B. Porcelain tile: Provide rectified tiles.
 - 1. Meeting ANSI A137.1, Section 4.1 Impervious Class, and Section 6.1 Table 10, Standard Grade.
 - 2. Color: Match colors scheduled in Finish Schedule.

3. Nominal face size: As scheduled on drawings.
4. Thickness: Minimum 3/8".
5. Finish: As scheduled on drawings.
6. Dynamic coefficient of friction (DCOF) for floor tile:
 - a. Tested in accord with the DCOF AccuTest, and meeting ANSI A137.1 and recommendations of ADA Accessibility Guidelines.
 - b. DCOF minimum: 0.42.
7. Trim shapes: Matching tile in color and size. Include coved base, coved bullnose base, bullnose caps, beads and corner units, as required.

2.3 SETTING MATERIALS AND ACCESSORIES:

- A. Premium latex-modified thinset mortar for floor tile with all dimensions less than 15":
 1. Acceptable products:
 - a. Custom Building Products, ProLite Premium Mortar.
 - b. H.B. Fuller Construction Products, TEC IsoLight Crack Isolation Mortar.
 - c. Mapei Corp., UltraFlex 3.
 - d. Basis of design; Laticrete, 3701, 4-XLT, or 254 Platinum Fortified Mortar bed.
 2. Characteristics: Pre-sanded, polymer-modified Portland cement and additives meeting ANSI A118.4 and ANSI A118.11, minimum 200 psi shear strength for porcelain tile at 28 days.
- B. LHT large and heavy tile (medium bed) premium polymer-modified Portland cement mortar for floor tile and wall tile with any dimension 15" or larger:
 1. Acceptable products:
 - a. Custom Building Products, ProLite Premium Mortar.
 - b. H.B. Fuller Construction Products, TEC 3N1 Performance Mortar.
 - c. Mapei Corp., Ultraflex LFT Mortar.
 2. Characteristics: Pre-sanded, polymer-modified Portland cement and additives meeting ANSI A118.4, ANSI A118.11 and ANSI A118.15, minimum 400 psi shear strength for porcelain tile at 28 days.
- C. Premium latex-modified thinset mortar for walls:
 1. Acceptable products:
 - a. Custom Building Products, ProLite Premium Mortar.
 - b. H.B. Fuller Construction Products, TEC 3N1 Performance Mortar.
 - c. Mapei Corp., UltraFlex LFT.
 - d. Basis of design; Laticrete, 254 Platinum.
 2. Characteristics: Non-sag, pre-sanded, polymer-modified Portland cement and additives meeting ANSI A118.4, ANSI A118.11 and ANSI A118.15, non-sag, minimum 400 psi shear strength for porcelain tile at 28 days.
- D. Combination membrane waterproofing and crack isolation membranes for LHT (medium-bed) set and thinset tile applications (excluding relocation of sawcut joints):
 1. Acceptable products:
 - a. The Noble Co., NobleSeal TS.
 - b. Compotite Corporation, Composeal Gold.
 - c. Custom Building Products, RedGard Fluid-Applied Waterproofing and Crack Prevention Membrane.
 - d. H.B. Fuller Construction Products, TEC HydraFlex Waterproofing Crack Isolation Fluid Membrane.
 - e. Mapei Corp., Mapelastic Aqua Defense.
 2. Characteristics: Minimum 30 mil thickness elastomeric membrane meeting ANSI A118.10.
 3. Provide manufacturer's standard solvents, adhesives and accessories as required for complete installation with a VOC content of 65 g/L or less.

2.4 GROUTING MATERIALS:

- A. Grout for all locations except where epoxy grout is used:
 1. Basis of design; Custom Building Products, Fusion Pro™ Single Component Grout™.

2. Characteristics: Single component advanced acrylic plus silicone resin with silica fillers and inorganic pigments grout with stain resistance and color consistency; meeting ANSI A118.7 and A118.3.
 3. Color: as selected by Architect.
- B. Epoxy grout for all floor tile and for wall tile in wet areas:
1. Acceptable products; standard epoxy grout:
 - a. Custom Building Products, CEG-Lite 100% Solids Commercial Epoxy Grout.
 - b. H. B. Fuller Construction Products, TEC AccuColor EFX Epoxy Special Effects Grout.
 - c. Mapei Corp., Kerapoxy or Kerapoxy CQ.
 - d. Laticrete, Spectralock Pro Grout.
 2. Characteristics: 100% epoxy, two-part or three-part composition meeting ANSI A118.3, with a VOC content of 65 g/L or less when calculated according to 40 CFR 59, Subpart D; standard colors selected by Architect.
 3. Grout release agent: Provide grout manufacturer's recommended grout release agent, for application prior to grouting tile to receive epoxy grout.

2.5 CONTROL AND EXPANSION JOINT MATERIALS:

- A. Acceptable products:
1. Pecora Corp., Dynatrol II.
 2. MBCC Group (Master Builders Construction Chemicals), MasterSeal NP-2.
 3. Custom Building Products, 100% Silicone Caulk.
 4. Tremco, Inc., Dymeric.
 5. Mapei, Mapeflex p1 sl (urethane).
 6. Mapei, Mapesil T (silicone).
- B. Characteristics:
1. Type; Contractor's option:
 - a. Urethane: Two-part, polyurethane-based sealant with separate pre-packaged color agent; VOC Content of not more than 250 g/L when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - b. Silicone: One-part silicone caulk meeting ASTM C920-14, Shore A Hardness of 35+, Type S, Grade NS, Class 25, Use T, I, M & G and ASTM C794-10 properties.
 2. Colors: Colors as scheduled on the drawings.
- C. Primer: Types recommended by sealant manufacturer:
1. Sealant primers for nonporous substrates: 250 g/L.
 2. Sealant primers for porous substrates: 775 g/L.
- D. Backup material: Flexible, non-compressive foam type as recommended by sealant manufacturer.

2.6 ACCESSORY MATERIALS:

- A. Marble thresholds: Meeting MIA Group A, honed finish, in sizes and shapes indicated; types and colors as selected by Architect.
- B. Trim and transition profiles:
1. Basis of design is Schluter Systems L.P. Products of other manufacturers may be submitted for Architect's consideration, subject to compliance with specified requirements and Architect's approval.
 2. Horizontal edge protection and transition profiles:
 - a. Basis of design: Schluter, profiles as indicated in Finish Schedule in drawings, with integral perforated anchoring leg.
 - b. Description: Brushed stainless steel and Polished Chrome.
 3. TS-6 Transition Strip: Schluter SCHIENE, anodized aluminum at carpet to porcelain tile, confirm depth with scheduled finishes.
 4. TS-7 Transition Strip Schluter SCHIENE, anodized aluminum at wall tile outside corner conditions, full height, confirm depth with scheduled finishes.

- C. Cleaning materials and methods for face of epoxy-grouted tile: Provide grout cleaning materials and methods in accord with manufacturer's product data.
- D. Grout sealer except at epoxy grout joints: Manufacturer's standard grout sealer which does not change color or appearance of grout. Subject to compliance with requirements of this specification, provide named products and systems or comparable products and systems by one of following manufacturers:
 - 1. Bostik Findley; "CeramaSeal® Magic Seal™ Grout Sealer".
 - 2. Custom Building Products; "TileLab® SurfaceGard® Penetrating Sealer".
 - 3. Southern Grouts & Mortars, Inc; "Grout Sealer-Premium Stain Blocker".
 - 4. Summitville Tiles, Inc.; "SL-99 SummitSeal II".
- E. Leveling compound; acceptable products: Portland based, free flowing, self-leveling compound.
 - 1. Acceptable products:
 - a. Custom Building Products, LevelQuik RS.
 - b. Euclid Chemical Co., Super Flo-Top.
 - c. H.B. Fuller Construction Products, TEC Level Set 200.
 - d. Mapei, Ultraplan 1 Plus.
 - 2. Characteristics: Fast-setting, self-leveling underlayment, minimum 28-day compressive strength of 4,000 psi.
 - 3. Provide primers for leveling compound as recommended or required by leveling compound manufacturer's product data.

PART 3 - EXECUTION

3.1 EXAMINATION:

- A. Subfloor curing:
 - 1. Concrete subfloors shall be moisture-cured or cured using a curing compound in accord with the requirements of the Section 03 3000 - Cast-In-Place Concrete.
 - 2. If a curing compound has been used, Contractor shall verify that compound is compatible with flooring manufacturer's installation materials.
 - 3. If the curing compound is not compatible, or if compatibility is unknown, Contractor shall remove curing compound by shot-blasting or other methods approved by floor finish manufacturer.
- B. Concrete moisture vapor emission, humidity levels and pH testing: Perform one or more of the following tests, as required by flooring manufacturer's product data, using the following methods:
 - 1. Moisture vapor emissions: Perform tests on subfloors in accord with ASTM F1869-04 calcium chloride test and flooring manufacturer's product data, to determine if surfaces are acceptable to receive specified flooring products.
 - 2. Humidity level: Perform on subfloors in accord with ASTM F2170-02 *in situ* probe and flooring manufacturer's product data, to determine if surfaces are acceptable to receive specified flooring products.
 - 3. Concrete pH level: Perform on subfloors to verify that surfaces are acceptable to receive specified flooring products.
 - 4. Correction of conditions: Prior to installation, correct conditions that do not meet flooring manufacture's requirements, or that may be detrimental to flooring installation.
- C. Conditions of surfaces to receive tile:
 - 1. Surfaces shall be firm, dry, clean and free of oily or waxy films.
 - 2. Grounds, anchors, plugs, hangers, bucks, electrical and mechanical work in or behind tile shall be installed prior to proceeding with tile work.

3.2 GENERAL TILE INSTALLATION:

- A. Install tile in accord with ANSI A108.1 through A108.11 and as specified herein.

- B. Layout:
1. Center tile within areas to avoid tiles of unequal widths at opposite walls and tiles of less than 1/2 tile width.
 2. Align tile joints straight and parallel to walls.
 3. Align joints in floor and base or wall tile.
 4. Locate accessories, control joints and expansion joints before installing tile.
- C. Cutting and fitting:
1. Cut and drill tiles without damaging exposed tile face. Rub cut edges smooth with Carborundum stone.
 2. Grind and fit tile at intersections, against trim and at built-in fixtures and accessories.
 3. Fit tile around outlets, pipes, fixtures and fittings so that tile edges are concealed under applied escutcheons, collars or plates.
 4. Miter coved and bullnose tile in corners or use special trim shapes to maintain uniform joint widths.
- D. Joints:
1. Provide uniform grout joint 1/8" minimum widths equal to pre-spaced tile for ceramic tile and glazed wall tile.
 2. Provide 1/4" wide joints for unglazed paver porcelain tile, unless indicated otherwise.
 3. In internal vertical corners of wall tile and where tile abuts dissimilar materials, form joints using control joint filled with sealant in lieu of grout.
- E. Control and expansion joints:
1. Ascertain that control and expansion joints are located in accord with approved shop drawings, TCNA EJ171-18, and as approved in advance by Architect.
 2. Provide control joints, perimeter control joints and expansion joints through tile and setting bed.
 - a. Field of floor control joints shall be located as follows:
 - 1) Spacing indicated, but not less than the following:
 - a) Interior dry areas: 20'-0" to 25'-0" o. c. in each direction.
 - b) Interior wet areas: 8'-0" to 12'-0" o. c. in each direction.
 - c) Exterior: 8'-0" to 12'-0" o. c. in each direction.
 - 2) Over cold joints and saw-cut control joints.
 - b. Provide control joints at all perimeters.
 - c. Locations of joints shall be as approved in advance by Architect. Width of joints shall match width of grout joints, except control joint shall be not less than 1/8" wide.
 3. Prime joints in accord with sealant manufacturer's product data. Following tile work completion, seal joints in accord with TCNA EJ171-18, using specified sealant.
- F. Tolerances:
1. Allowable lippage: Comply with ANSI A108.02 as follows:
 - a. Glazed wall tile/mosaic tile: 1/32".
 - b. Pressed floor tile and porcelain tiles, joint width less than 1/4": 1/32".
 - c. Pressed floor tile and porcelain tiles, joint width 1/4" or greater: 1/16".
 2. Allowable site installation tolerances: Plumb, level and true to line, meeting ANSI A108.02 as follows:
 - a. For tile with all dimensions less than 15": Maximum 1/16" in 1'-0" and maximum 1/4" in 10'-0".
 - b. For tile with any dimension greater than 15": Maximum 1/16" in 2'-0" and maximum 1/8" in 10'-0".
- G. Grout release agent: Prior to grouting tile to receive epoxy grout, apply specified grout release agent to face of tile only. Do not allow agent to migrate into joints.

3.3 TILE INSTALLATION:

- A. Floor tile with any dimension 15" or larger, medium bed set, interior:
1. Setting method: Medium-bed latex Portland cement mortar.

2. Standard installation method: Generally in accord with TCNA F115-18 for epoxy grout.
 3. Grout type; Epoxy grout. Apply grout release agent prior to grouting tile to receive epoxy grout.
- B. Slab-on-grades floor tile and pavers; thinset, interior:
1. Setting method: Premium latex-modified thinset mortar.
 2. Standard installation method: TCNA F115-18.
 3. Grout type; Epoxy grout. Apply grout release agent prior to grouting tile to receive epoxy grout.
- C. Elevated floor tiles; Thin-Set and Medium-Set: ANSI A108.5 and TCNA Method F125A-16 (isolation crack membrane).
1. Install membrane for thin-set and medium set floor tile over upper level concrete slabs with joints lapped minimum 4". Secure to supporting walls. Butt tight to walls and fitments.
 2. Apply mortar bond coat setting bed to nominal 3/32" thickness, and in no case greater than 3/4" thick.
 3. Grout type; Epoxy grout. Apply grout release agent prior to grouting tile to receive epoxy grout.
- D. Wall tile and base, thinset over gypsum board, interior:
1. Setting method: Premium latex-modified thinset mortar.
 2. Standard installation method: TCNA W243-18.
 3. Grout types: Polymer modified unsanded cement grout for minimum 1/8" wide joints.
- E. Wall tile and base, thinset over cement backer board, interior:
1. Setting method: Premium polymer-modified thinset mortar on cement backer board over studs.
 2. Standard installation method: TCNA W244C-18.
 3. Grout types:
 - a. Dry areas: Premium rapid-setting high performance grout.
 - b. Wet areas: Epoxy grout. Apply grout release agent prior to grouting tile to receive epoxy grout.

3.4 CLEANING AND PROTECTION:

- A. Clean tile as work progresses, preventing accumulation of setting and grouting materials or debris on tile faces.
- B. Immediately remove stains, grout release agent, excess mortar, grout and sealant from faces of tile; comply with manufacturer's product data.
- C. Glazed tile: Clean glazed tile using a solution of detergent and water only. Use no acids to clean glazed tile.
- D. Unglazed tile:
1. Allow tile work to cure a minimum of 14 days prior to acid cleaning.
 2. Saturate grout joints with clean water at least two hours prior to beginning acid cleaning. Apply a grease coating to metal and vitreous surfaces subject to contact with acid solution.
 3. Utilize a solution of one pound sulfamic acid to five gallons clean water for cleaning in accord with ANSI A137.1, Section 3.5.3. Work in areas not exceeding 20 sq. ft., scrubbing tile surfaces to remove residue. Do not scrub grout joints.
 4. Flush cleaned areas with water immediately after cleaning. Scrub surfaces with clean water to remove remaining film.
 5. Do not reuse cleaning solutions. Discard solutions containing residue and debris from cleaning operations so as not to contaminate or stain adjacent work.

- E. Grout sealer except epoxy grout: Apply grout sealer to cementitious grout joints in compliance with grout sealer manufacturer's written instructions. As soon as grout sealer has penetrated grout joints, remove excess sealer and sealer that has gotten onto tile faces by wiping with soft cloth.
- F. Protection: Protect installed tile work until Date of Substantial Completion by covering with kraft paper.

END OF SECTION

SECTION 09 5100 - ACOUSTICAL CEILINGS

PART 1 - GENERAL

1.1 ACTION SUBMITTALS:

- A. Shop Drawings: Submit reflected ceiling plans and details of acoustical ceilings. Show joint pattern, ceiling suspension system members, method of attaching hangers to building structure. Include location of all items indicated to penetrate the suspended ceiling system, including but not limited to: light fixtures; air outlets and inlets, speakers, sprinkler heads, and special moldings at walls, column penetrations, and other junctures with adjoining construction.
- B. Product data: Include product descriptions and installation instructions for each material. Indicate load carrying capacity of suspension system hanger spacings and manufacturer's recommended methods for fixture support.
- C. Samples for Verification: For each component indicated and for each exposed finish required, prepared on Samples of sizes indicated below:
 - 1. Acoustical Panels: Set of 6-inch-square samples of each type, color, pattern, and texture.
 - 2. Exposed Suspension-System Members, Moldings, and Trim: Set of 6-inch long Samples of each type, finish, and color.
 - 3. Clips: One of each size and type.

1.2 INFORMATIONAL SUBMITTALS:

- A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Ceiling suspension-system members.
 - 2. Structural members to which suspension systems will be attached.
 - 3. Method of attaching hangers to building structure.
 - 4. Carrying channels or other supplemental support for hanger-wire attachment where conditions do not permit installation of hanger wires at required spacing.
 - 5. Size and location of initial access modules for acoustical panels.
 - 6. Items penetrating finished ceiling and ceiling-mounted items including the following:
 - a. Lighting fixtures.
 - b. Diffusers.
 - c. Grilles.
 - d. Speakers.
 - e. Sprinklers.
 - f. Access panels.
 - g. Perimeter moldings.
 - 7. Show operation of hinged and sliding components covered by acoustical panels.
 - 8. Minimum Drawing Scale: 1/8 inch = 1 foot.
- B. Qualification Data: For testing agency.
- C. Product Test Reports: For each acoustical panel ceiling, for tests performed by a qualified testing agency.
- D. Evaluation Reports: For each acoustical panel ceiling suspension system from ICC-ES.
- E. Field quality-control reports.
- F. Maintenance Data: For finishes to include in maintenance manuals.
- G. Certificates: Indicate compliance with specified requirements.

1.3 QUALITY ASSURANCE:

- A. Applicable standards; standards as referenced herein:
 - 1. American Iron and Steel Institute (AISI).
 - 2. ASTM International (ASTM).
 - 3. Ceiling & Interior Systems Contractors Association (CISCA).
 - 4. Underwriters Laboratories, Inc. (UL).
- B. Obtain acoustical panels and supporting suspension system through one source from a single manufacturer. Each type of acoustical panel and painted grid shall be from a single production run.

1.4 PROJECT/SITE CONDITIONS:

- A. Sequencing and scheduling: Schedule acoustical material installation to minimize need for removal and replacement of acoustical units to accommodate work of other trades.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS:

- A. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame-Spread Index: Comply with ASTM E1264 for Class A.
 - 2. Smoke-Developed Index: 450 or less.
- B. Fire-Resistance Ratings: Comply with ASTM E119; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Indicate design designations from UL's "Fire Resistance Directory" or from the listings of another qualified testing agency.

2.2 METAL SUSPENSION SYSTEMS, GENERAL:

- A. Metal suspension system standard: Provide manufacturer's standard direct-hung metal suspension systems of types, structural classifications, and finishes indicated that comply with applicable requirements in ASTM C635-12.
- B. Attachment devices: Size for five times the design load indicated in ASTM C635-12, Table 1, "Direct Hung," unless otherwise indicated. Comply with seismic design requirements.
 - 1. Anchors in concrete: Anchors of type and material indicated below, with holes or loops for attaching hangers of type indicated and with capability to sustain, without failure, a load equal to five times that imposed by ceiling construction, as determined by testing according to ASTM E488-10 or ASTM E1512-01(2007) as applicable, conducted by a qualified testing and inspecting agency.
 - a. Type: Cast-in-place anchors.
 - b. Corrosion protection: Carbon-steel components zinc plated to comply with ASTM B633-11, Class Fe/Zn 5 (0.005 mm) for Class SC 1 service condition.
 - 2. Power-actuated fasteners in concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hangers of type indicated and with capability to sustain, without failure, a load equal to 10 times that imposed by ceiling construction, as determined by testing according to ASTM E1190-11, conducted by a qualified testing and inspecting agency.
 - 3. Hanger clips: Prefabricated metal clamps for fastening to building structure.
- C. Wire hangers, braces, and ties: Provide wires complying with the following requirements:
 - 1. Zinc-coated, carbon steel wire: ASTM A641-09a, Class 1 zinc coating, soft temper.

2. Size: Select wire diameter so its stress at three times hanger design load (ASTM C635-12, Table 1, "Direct Hung") will be less than yield stress of wire, but provide not less than 0.106-inch diameter wire.
- D. Special shapes:
 1. Acceptable manufacturers; subject to compliance with specified requirements:
 - a. Fry Reglet Corp.
 - b. Gordon, Inc.
 - c. Pittcon Industries.
 2. Characteristics: Aluminum acoustical moldings, shapes as indicated; white color.

2.3 STEEL SUSPENSION SYSTEMS:

- A. Acceptable manufacturers; subject to compliance with specified requirements:
 1. Armstrong World Industries, Inc.
 2. CertainTeed Corp.
 3. Rockfon (formerly Chicago Metallic Corp.)
 4. USG Interiors, Inc.
- B. Exposed steel grid system; 15/16" flange face.
 1. Structural classification: Prelude XL, 15/16" flange face. Meeting ASTM C635-13a, Intermediate Duty for interior applications.
 2. Module: 2'-0" by 2'-0".
 3. Main and cross tees:
 - a. Tee material: Hot dip galvanized, cold-rolled steel.
 - b. Cap material: Aluminum.
 - c. Design: Double web.
 - d. Tee size: 15/16" flange face width; 1-1/2" nominal height main tees.
 - 1) 2'-0" or 4'-0" long cross tees for interior applications.
 - 2) Material thicknesses shall be as required to meet specified structural classifications.
 4. Edge molding:
 - a. For square edge panels: Minimum 0.020" thickness galvanized steel, channel or angle shaped, hemmed edges.
 - b. Flange widths: Minimum 3/4".
 5. Finish on exposed components: Chemically treated for paint adhesion with factory-applied, low-gloss white paint.
- C. Finish on exposed components: Chemically treated for paint adhesion with factory-applied, low-gloss white paint.

2.4 ACOUSTICAL PANELS, GENERAL:

- A. Source limitations:
 1. Acoustical ceiling panels: Obtain each type from single source from single manufacturer.
 2. Suspension system: Obtain each type from single source from single manufacturer.

2.5 ACOUSTICAL CEILING PANELS; ACT-1:

- A. Acceptable manufacturers; subject to compliance with specified requirements:
 1. Basis of design: Armstrong World Industries, Inc.
 2. CertainTeed Corp.
 3. USG Interiors, Inc.
- B. ACT-1; #1713 School Zone Fine Fissured™ High NRC, Medium Texture; square edge, lay-in acoustical panels for use with Prelude XL 15/16" exposed grid.
 1. Size: 24" x 24".
 2. Thickness: 3/4".
 3. NRC: 0.70.

4. CAC: 35.
5. Fire Performance: Class A.
6. Light Reflectance: 0.85.

2.6 ACCESSORIES:

- A. Acoustical sealant:
 1. Acoustical sealant for exposed and concealed joints: Manufacturer's standard nonsag, paintable, nonstaining latex sealant complying with ASTM C834-10 and effective in reducing airborne sound transmission through perimeter joints and openings in building construction as demonstrated by testing representative assemblies according to ASTM E90-09.
 2. Acoustical sealant for concealed joints: Manufacturer's standard nondrying, nonhardening, nonskinning, nonstaining, gunnable, synthetic-rubber sealant recommended for sealing interior concealed joints to reduce airborne sound transmission.
- B. Sound attenuation blankets: 1-1/2" thickness, minimum 2-1/2 lb. density, paperless, semi-rigid, mineral fiber blanket.
- C. T-Grid support clip:
 1. Acceptable products:
 - a. Armstrong World Industries, Inc., Beam End Retainer Clip Item 7395.
 - b. Chicago Metallic corp., Perimeter clip 1499.
 - c. Erico Products, Inc., Caddy TGE T-Grid support clip.
 - d. USG Industries, Inc., Mac 2.
 2. Characteristics: Mechanical clip for attaching acoustical "T" to edge molding without exposed fasteners in grid system.

PART 3 - EXECUTION

3.1 SUSPENSION SYSTEM INSTALLATION:

- A. Install suspension system in accord with manufacturer's product data, ASTM C636-08, ASTM E580-11b and CISCA recommendations, except for more stringent requirements specified herein.
- B. Layout:
 1. Center grid system within areas to avoid panels of unequal widths at opposite walls and panels of less than 1/2 width.
 2. Align grid members straight and perpendicular to walls.
 3. Locate accessories, control joints and expansion joints before installing grid system.
- C. Hangers:
 1. Space hangers for carrying channels or main tees at 4'-0" o. c. maximum. Secure to building structure.
 2. Install additional hangers at ends of each suspension member, within 6" of end of member or wall.
 3. Install additional hangers within 6" of each corner of lighting fixtures, grilles and similar items.
 4. Splay wires no more than 5" in 2'-6" vertical drop.
 5. Where spacing of hangers for main tees exceeds maximum specified spacing due to interference by adjacent construction, indirect-hang tees using carrying channels to maintain maximum hanger spacing.
 6. Wrap wire minimum of three times horizontally, turning ends upwards.

- D. Direct-hung, grid system, 2'-0" by 2'-0" module:
 - 1. Space main tees at 4'-0" o. c., maximum, perpendicular to structure.
 - 2. Locate cross tees at 2'-0" o. c., perpendicular to main tees.
 - 3. Space cross tees at 2'-0" o. c., perpendicular to previously installed cross tees, to form 2'-0" by 2'-0" grid module. Connect to cross tees through slots in main tees.
- E. Level and square suspension system components within specified tolerances prior to beginning ceiling material installation.
- F. Install cross tees adjacent to lighting fixtures and grilles on each side not supported by main tees. Support no fixtures on main or cross tees when fixture weight results in dead load exceeding deflection capacity of suspension system.
- G. Where cut tees intersect other tees or edge moldings without mechanical attachment, attach components using T-Grid support clip. At contractor's option tees may be attached directly to partition with tie wire.
- H. Wall moldings:
 - 1. Install wall molding at intersection of suspended ceiling and vertical surfaces. Install suspension members on bottom leg of shadowline edge molding.
 - 2. Miter corners where wall moldings intersect or install corner caps.
 - 3. Attach to vertical surfaces with mechanical fasteners.
 - 4. Apply continuous ribbon of acoustical sealant on vertical web where space above ceiling is a plenum.
- I. Where grid system exists in an unrestrained condition, brace back to building structure using hanger wire, main tee or carrying channel braces spaced at 4'-0" o. c., maximum.

3.2 ACOUSTICAL UNIT INSTALLATION:

- A. Install acoustical units in level plane, in straight line courses, within specified tolerances.
- B. Place acoustical materials to bear all around on suspension members.
- C. Pattern shall be symmetrical about centerline of area, unless otherwise indicated. Lay out units having directional pattern in same direction.
- D. Seal joints in acoustical units around pipes, ducts, and ducts and electrical outlets with acoustical sealant where ceiling is used as supply or return air plenum.
- E. Where cutting of acoustical units is required, cut so that no cut or damaged edges are visible in finished work.
- F. Hold-down clips: Install acoustical units surrounding recessed troffer lights with hold-down clips to prevent movement or displacement of units.
- G. Lay sound attenuation blankets over ceilings in designated spaces.
- H. Allowable tolerances:
 - 1. Deflection: Suspension system components, hangers and fastening devices supporting lighting fixtures, ceiling grilles and acoustical units shall have maximum deflection of 1/360 of the span when tested in accord with ASTM C635-12.
 - 2. Bow, camber and twist: Not exceeding tolerances established by ASTM C635-12.
 - 3. Variation from level in finished ceiling: $\pm 1/8$ " in 12'-0".

3.3 MAINTENANCE MATERIALS:

- A. Furnish extra materials equal to one percent of each type of acoustical material supplied.
- B. Furnish suspension system components in amount sufficient to install extra ceiling units.

3.4 CLEANING:

- A. Clean soiled or discolored unit surfaces after installation.
- B. Touch up scratches, abrasions, voids and other defects in painted metal surfaces.
- C. Remove and replace damaged and stained acoustical units with new units.

END OF SECTION

SECTION 09 6513 - RESILIENT BASE AND ACCESSORIES

PART 1 - GENERAL

1.1 ACTION SUBMITTALS:

- A. Product data: Indicate product characteristics and installation requirements, including manufacturer's recommended adhesives and maintenance instructions.
- B. Samples: Submit full size samples for each type color and pattern of base and accessor required.

1.2 QUALITY ASSURANCE:

- A. Applicable standards, as referenced herein: ASTM International (ASTM).

1.3 PROJECT/SITE CONDITIONS:

- A. Environmental requirements:
 - 1. Maintain temperature in space to receive resilient materials at not less than 70°F for not less than 24 hours before, during and for 48 hours after installation.
- B. Protection: Protect finished base and accessories from staining, marring or other physical damage by work of other trades. Cover or mask surfaces as required.

PART 2 - PRODUCTS

2.1 B-1; BASE:

- A. Acceptable manufacturers:
 - 1. Burke Flooring, a Div. of Burke Industries.
 - 2. Johnsonite, Inc.
 - 3. Marley Flexco (USA), Inc.
 - 4. Basis of design; Roppe Corp.
- B. B-1; Rubber base: Roppe Corp. Roppe color:, 4" H roll good, cove base.
 - 1. Type: Minimum 48% rubber, 100% vulcanized; meeting ASTM F1861, Type TS Thermoset Vulcanized Rubber SBR.
 - 2. Length: Minimum 120'-0" rolls.
 - 3. Thickness: 1/8".
 - 4. Height: 4".
 - 5. Style: Coved.
 - 6. Colors: 193 Black/Brown.
- C. Corners: Preformed outside corners. Preformed corners shall match base in color, sheen and overall appearance.

2.2 ACCESSORIES:

- A. Acceptable manufacturers:
 - 1. Burke Flooring Products, a Div. of Burke Industries.
 - 2. Marley Flexco (USA), Inc.
 - 3. Johnsonite, Inc.
 - 4. R. C. Musson Rubber Co.
 - 5. Basis of design; Roppe Corp.
- B. TS-5; Transition strip:
 - 1. Basis of design; Roppe Corp., #35 Edge Guard underlap carpet edge. ADA Compliant.
 - 2. Material: Rubber.
 - 3. Color: Match B-1 Base.

2.3 INSTALLATION MATERIALS:

- A. Leveling compound:
 - 1. Acceptable products:
 - a. Custom Building Products, LevelQuik RS.
 - b. H.B. Fuller Construction Products, TEC Level Set 200.
 - c. Mapei, Ultraplan 1 Plus.
 - 2. Characteristics: Fast-setting, self-leveling underlayment, minimum 28-day compressive strength of 4,000 psi.
 - 3. Provide primers for leveling compound as recommended or required by leveling compound manufacturer's product data.
- B. Adhesives: Water-resistant type recommended by manufacturer to suit resilient products and substrate conditions indicated.
 - 1. Use adhesives that comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24): Not more than 50 g/L.

PART 3 - EXECUTION

3.1 PREPARATION:

- A. Prepare surfaces to receive resilient material in accord with manufacturer's instructions.
- B. Grind high areas and fill depressions with leveling compound where required to produce smooth installation and for proper alignment with adjacent flooring materials.
- C. Remove dirt, oil, grease or other foreign matter from surfaces to receive base or accessories.

3.2 APPLICATION OF ADHESIVES:

- A. Mix and apply adhesives in accord with resilient material manufacturer's product data. Apply with notched trowel or other tools as recommended by adhesive manufacturer.
- B. Provide safety precautions during mixing and applications as recommended by adhesive manufacturer.
- C. Apply adhesive to only that area which can be covered by resilient material within the recommended working time of the adhesive.
 - 1. Remove adhesive which dries or films over.
 - 2. Do not soil walls, bases or adjacent areas with adhesives.
 - 3. Remove spilled or misplaced materials.

3.3 INSTALLATION OF BASE:

- A. Workmanship:
 - 1. Unroll base material and allow to relax for 24 hours, minimum, prior to installation. Cut into lengths for minimum number of joints. Double-cut adjoining lengths.
 - 2. Install with tight butt joints with no joint widths greater than 1/64".
- B. Top-set base:
 - 1. Apply adhesive and adhere to vertical surfaces.
 - 2. Press down so that bottom edge follows floor profile.
 - 3. Form internal corners by coping and bending sufficient length around corner for anchorage.
 - 4. Form external corners using premolded corners.
 - 5. Scribe base to abutting materials.

3.4 ACCESSORY INSTALLATION:

- A. Cut materials to lengths and sizes indicated.

- B. Resilient reducers:
 - 1. Apply adhesives and bond to substrate.
 - 2. Center thresholds and reducers in door openings.
 - 3. Fit edge to door frame jambs without visible gaps or cracks.
 - 4. Fit edges to abutting floor materials for flush fit.

3.5 CLEANING:

- A. Upon completion of installation, clean surfaces using a neutral cleaner acceptable to material manufacturer.

END OF SECTION

SECTION 09 65 00

RESILIENT FLOORING

08/10

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D4078	(2002; R 2015) Water Emulsion Floor Polish
ASTM E648	(2017a) Standard Test Method for Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source
ASTM F710	(2019) Standard Practice for Preparing Concrete Floors to Receive Resilient Flooring
ASTM F1344	(2015) Rubber Floor Tile
ASTM F1482	(2015) Installation and Preparation of Panel Type Underlayments to Receive Resilient Flooring
ASTM F1861	(2016) Standard Specification for Resilient Wall Base
ASTM F1869	(2016) Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride
ASTM F2169	(2015; E 2016) Standard Specification for Resilient Stair Treads
ASTM F2170	(2019) Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using in situ Probes

CALIFORNIA DEPARTMENT OF PUBLIC HEALTH (CDPH)

CDPH SECTION 01350	(2010; Version 1.1) Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources using Environmental Chambers
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GREEN SEAL (GS)

GS-36	(2013) Adhesives for Commercial Use
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SCIENTIFIC CERTIFICATION SYSTEMS (SCS)

SCS SCS Global Services (SCS) Indoor Advantage

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT (SCAQMD)

SCAQMD Rule 1168 (2017) Adhesive and Sealant Applications

UNDERWRITERS LABORATORIES (UL)

UL 2818 (2013) GREENGUARD Certification Program
For Chemical Emissions For Building
Materials, Finishes And Furnishings

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Resilient Flooring and Accessories; G

SD-03 Product Data

Resilient Flooring and Accessories; G

Adhesives

SD-04 Samples

Resilient Flooring and Accessories; G

SD-06 Test Reports

Moisture, Alkalinity and Bond Tests; G

SD-07 Certificates

Indoor Air Quality for Adhesives

SD-08 Manufacturer's Instructions

Surface Preparation; G

Installation; G

SD-10 Operation and Maintenance Data

Resilient Flooring and Accessories; G

1.3 CERTIFICATES

1.3.1 Indoor Air Quality

Submit required indoor air quality certifications and validations in one

submittal package.

1.3.1.1 Floor Covering Materials

Provide Rubber Tile, and wall base products certified to meet indoor air quality requirements by FLOORSCORE, UL 2818 (Greenguard) Gold, SCS Global Services Indoor Advantage Gold or provide certification by other third-party programs. Provide current product certification documentation from certification body.

1.3.1.2 Adhesives, Caulking and Sealants

Provide products certified to meet indoor air quality requirements by UL 2818 (Greenguard) Gold, SCS Global Services Indoor Advantage Gold or provide certification or validation by other third-party programs that products meet the requirements of this Section. Provide current product certification documentation from certification body. When product does not have certification, provide validation that product meets the indoor air quality product requirements cited herein.

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver materials to the building site in original unopened containers bearing the manufacturer's name, style name, pattern color name and number, production run, project identification, and handling instructions. Store materials in a clean, dry, secure, and well-ventilated area with ambient air temperature maintained above 68 degrees F and below 85 degrees F, stacked according to manufacturer's recommendations. Protect materials from the direct flow of heat from hot-air registers, radiators and other heating fixtures and appliances. Observe ventilation and safety procedures specified in the MSDS. Do not store near materials that may offgas or emit harmful fumes, such as kerosene heaters, fresh paint, or adhesives.

1.5 ENVIRONMENTAL REQUIREMENTS

Maintain areas to receive resilient flooring at a temperature above 68 degrees F and below 85 degrees F for 3 days before application, during application and 2 days after application, unless otherwise directed by the flooring manufacturer for the flooring being installed. Maintain a minimum temperature of 55 degrees F thereafter. Provide adequate ventilation to remove moisture from area and to comply with regulations limiting concentrations of hazardous vapors.

1.6 SCHEDULING

Schedule resilient flooring application after the completion of other work which would damage the finished surface of the flooring.

1.7 WARRANTY

Provide manufacturer's standard performance guarantees or warranties that extend beyond a one year period.

1.8 EXTRA MATERIALS

Provide extra flooring material of each color and pattern at the rate of 5 tiles for each 1000 tiles installed. Provide extra wall base material composed of 20 linear feet of each type, color and pattern. Package all

extra materials in original properly marked containers bearing the manufacturer's name, brand name, pattern color name and number, production run, and handling instructions. Provide extra materials from the same lot as those installed. Leave extra stock at the site in location assigned by Contracting Officer.

PART 2 PRODUCTS

2.1 RUBBER TILE

Conform to ASTM F1344 Class 1 homogeneous , Type A (solid color) , scheduled size. Provide 0.125 inch overall thickness.

2.2 WALL BASE

Conform to ASTM F1861, Type TS (vulcanized thermoset rubber) , Style A (straight - installed with carpet) , and Style B (coved - installed with resilient flooring) . Provide 4 inch high and a minimum 1/8 inch thick wall base. Provide preformed corners in matching height, shape, and color.

2.3 STAIR TREADS, RISERS AND STRINGERS

Conform to ASTM F2169, Type TS (vulcanized thermoset rubber) . Conform to ASTM F2169 for surface of treads . Provide scheduled nosing. Provide either a one piece nosing/tread/riser or a two piece nosing/tread design with a matching coved riser.

2.4 MOULDING

Provide tapered mouldings of rubber and types as recommended by flooring manufacturer for both edges and transitions of flooring materials specified. Provide vertical lip on moulding of maximum 1/4 inch. Provide bevel change in level between 1/4 and 1/2 inch with a slope no greater than 1:2.

2.5 ADHESIVES

Provide adhesives for flooring, base and accessories as recommended by the manufacturer and comply with local indoor air quality standards. Submit manufacturer's descriptive data, documentation stating physical characteristics, and mildew and germicidal characteristics.

Provide non-aerosol adhesive products used on the interior of the building (defined as inside of the weatherproofing system) that meet either emissions requirements of CDPH SECTION 01350 (limit requirements for either office or classroom spaces regardless of space type) or VOC content requirements of SCAQMD Rule 1168. Provide aerosol adhesives used on the interior of the building that meet either emissions requirements of CDPH SECTION 01350 (use the office or classroom requirements, regardless of space type) or VOC content requirements of GS-36. Provide certification or validation of indoor air quality for adhesives.

2.6 SURFACE PREPARATION MATERIALS

Provide surface preparation materials, such as panel type underlayment, lining felt, and floor crack fillers as recommended by the flooring manufacturer for the subfloor conditions. Comply with ASTM F1482 for panel type underlayment products.

2.7 POLISH/FINISH

Provide polish finish as recommended by the manufacturer and conform to ASTM D4078 for polish.

2.8 CAULKING AND SEALANTS

Provide caulking and sealants in accordance with Section 07 92 00 JOINT SEALANTS.

2.9 MANUFACTURER'S COLOR, PATTERN AND TEXTURE

Provide color, pattern and texture for resilient flooring and accessories in accordance with Section 09 06 00 SCHEDULES FOR FINISHES . Provide floor patterns as specified on the drawings. Provide flooring in any one continuous area or replacement of damaged flooring in continuous area from same production run with same shade and pattern. Submit scaled drawings indicating patterns (including location of patterns and colors) and dimensions. Submit manufacturer's descriptive data and three samples of each indicated color and type of flooring, base, mouldings, and accessories sized a minimum 2-1/2 by 4 inch. Submit Data Package 1 in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

2.10 FIRE RESISTANCE TESTING REQUIREMENTS

Provide a minimum average critical radiant flux of 0.45 watts per square centimeter for flooring in corridors and exits when tested in accordance with ASTM E648.

PART 3 EXECUTION

3.1 EXAMINATION

Examine and verify that site conditions are in agreement with the design package. Report all conditions that will prevent a proper installation. Do not take any corrective action without written permission from the Government. Work will proceed only when conditions have been corrected and accepted by the installer. Submit manufacturer's printed installation instructions for all flooring materials and accessories, including preparation of substrate, seaming techniques, and recommended adhesives.

3.2 SURFACE PREPARATION

Provide a smooth, true, level plane for surface preparation of the flooring, except where indicated as sloped. Floor to be flat to within 3/16 inch in 10 feet. Prepare subfloor in accordance with flooring manufacturer's recommended instructions. Prepare the surfaces of lightweight concrete slabs (as defined by the flooring manufacturer) as recommended by the flooring manufacturer. Comply with ASTM F710 for concrete subfloor preparation. Floor fills or toppings may be required as recommended by the flooring manufacturer. Install underlayments, when required by the flooring manufacturer, in accordance with manufacturer's recommended printed installation instructions. Comply with ASTM F1482 for panel type underlayments. Before any work under this section is begun, correct all defects such as rough or scaling concrete, chalk and dust, cracks, low spots, high spots, and uneven surfaces. Repair all damaged portions of concrete slabs as recommended by the flooring manufacturer. Remove concrete curing and sealer compounds from the slabs, other than the

type that does not adversely affect adhesion. Remove paint, varnish, oils, release agents, sealers, waxes, and adhesives, as required by the flooring product in accordance with manufacturer's printed installation instructions.

3.3 MOISTURE, ALKALINITY AND BOND TESTS

Determine the suitability of the concrete subfloor for receiving the resilient flooring with regard to moisture content and pH level by moisture and alkalinity tests. Conduct moisture testing in accordance with ASTM F1869 or ASTM F2170, unless otherwise recommended by the flooring manufacturer. Conduct alkalinity testing as recommended by the flooring manufacturer. Determine the compatibility of the resilient flooring adhesives to the concrete floors by a bond test in accordance with the flooring manufacturer's recommendations. Submit copy of test reports for moisture and alkalinity content of concrete slab, and bond test stating date of test, person conducting the test, and the area tested.

3.4 GENERAL INSTALLATION

Do not install building construction materials that show visual evidence of biological growth.

3.5 PLACING LUXURY VINYL TILES

Install flooring and accessories in accordance with manufacturer's printed installation instructions. Prepare and apply adhesives in accordance with manufacturer's directions for installation method specified. Keep tile lines and joints square, symmetrical, tight, and even. Keep each floor in true, level plane, except where slope is indicated. Vary edge width as necessary to maintain full-size tiles in the field, no edge tile to be less than one-half the field tile size, except where irregular shaped rooms make it impossible. Cut flooring to fit around all permanent fixtures, built-in furniture and cabinets, pipes, and outlets. Cut, fit, and scribe edge tile to walls and partitions after field flooring has been applied.

3.6 PLACING RUBBER TILE

Install rubber tile and accessories in accordance with manufacturer's printed installation instructions. Prepare and apply adhesives in accordance with manufacturer's printed directions. Provide square, symmetrical, tight, and even flooring lines and joints. Keep each floor in true, level plane, except where slope is indicated. Vary width of edge tiles as necessary to maintain full-size tiles, except where irregular-shaped rooms makes it impossible. Cut flooring to fit around all permanent fixtures, built-in furniture and cabinets, pipes, and outlets. Cut, fit, and scribe flooring to walls and partitions after field flooring has been applied.

3.7 PLACING RUBBER SHEET FLOORING

Install rubber sheet flooring and accessories in accordance with manufacturer's printed installation instructions. Prepare and apply adhesives in accordance with manufacturer's printed directions. Provide square, symmetrical, tight, and even flooring lines and joints. Keep each floor in true, level plane, except where slope is indicated. Cut seams by overlapping or underscribing as recommended by the manufacturer. Lay out sheets to minimize waste. Cut flooring to fit around all permanent

fixtures, built-in furniture and cabinets, pipes, and outlets. Cut, fit, and scribe flooring to walls and partitions after field flooring has been applied.

3.8 PLACING MOULDING

Provide moulding where flooring termination is higher than the adjacent finished flooring and at transitions between different flooring materials. When required, locate moulding under door centerline. Moulding is not required at doorways where thresholds are provided. Secure moulding with adhesive as recommended by the manufacturer. Prepare and apply adhesives in accordance with manufacturer's printed directions.

3.9 PLACING WALL BASE

Install wall base in accordance with manufacturer's printed installation instructions. Prepare and apply adhesives in accordance with manufacturer's printed directions. Tighten base joints and make even with adjacent resilient flooring. Fill voids along the top edge of base at masonry walls with caulk. Roll entire vertical surface of base with hand roller, and press toe of base with a straight piece of wood to ensure proper alignment. Avoid excess adhesive in corners.

3.10 PLACING STAIR TREADS, RISERS, AND STRINGERS

Secure and install stair treads, risers, and stringers in accordance with manufacturer's printed installation instructions. Cover the surface of treads and risers the full width of the stairs, unless directed otherwise. Provide equal length pieces butted together to cover the treads and risers for stairs wider than manufacturer's standard lengths.

3.11 CLEANING

Immediately upon completion of installation of flooring in a room or an area, dry and clean the flooring and adjacent surfaces to remove all surplus adhesive. Clean flooring as recommended in accordance with manufacturer's printed maintenance instructions and within the recommended time frame. As required by the manufacturer, apply the recommended number of coats and type of polish and finish in accordance with manufacturer's written instructions.

3.12 PROTECTION

From the time of installation until acceptance, protect flooring from damage as recommended by the flooring manufacturer. Remove and replace flooring which becomes damaged, loose, broken, or curled and wall base which is not tight to wall or securely adhered.

-- End of Section --

SECTION 09 6813 - CARPET TILE

PART 1 - GENERAL

1.1 ACTION SUBMITTALS:

- A. Shop drawings: Show columns, doorways, enclosing walls and partitions, built-in cabinets, and locations where cutouts are required in carpet. Indicate the following:
 - 1. Carpet type, color, and dye lot.
 - 2. Locations where dye lot changes occur.
 - 3. Seam locations, types, and methods.
 - 4. Type of subfloor.
 - 5. Type of installation.
 - 6. Pattern type, repeat size, location, direction, and starting point.
 - 7. Pile direction.
 - 8. Type, color, and location of insets and borders.
 - 9. Type, color, and location of edge, transition, and other accessory strips.
 - 10. Transition details to other flooring materials.
- B. Product data: Submit for carpet tile and installation accessories. Include test reports verifying that carpet meet(s) specified design criteria. Include manufacturer's specification data and installation procedures. Indicate primers, adhesives and seaming methods proposed for use. Should carpet manufacturer not publish detailed installation data, installer shall submit detailed proposed procedures for Architect's approval.
- C. Samples; identify carpet samples by name, number and manufacturer's lot number:
 - 1. Carpet tile: Submit two full-size samples of each type, color and pattern selected.
 - 2. Accessories: Submit 1'-0" length of carpet edge strip.

1.2 INFORMATIONAL SUBMITTALS:

- A. Certificates: Carpet shall be certified for compliance with specification requirements. Submit certificates from carpet manufacturer at time of carpet delivery to project site. Each certificate shall be signed by authorized officer of carpet manufacturing company and shall contain the name and address of the Contractor, the project location and the quantities and date or dates of shipment or delivery to which certificates apply.

1.3 CLOSEOUT SUBMITTALS:

- A. Maintenance data: Submit as part of Contract closeout documents. Include recommendations for various traffic conditions, cleaning procedures and intervals.

1.4 QUALITY ASSURANCE:

- A. Applicable standards; standards of the following, as referenced herein:
 - 1. American Association of Textile Chemists and Colorists (AATCC).
 - 2. ASTM International (ASTM).
 - 3. Department of Commerce (DOC).
 - 4. National Fire Protection Association (NFPA).
 - 5. The Carpet and Rug Institute (CRI).
- B. Design criteria; carpet shall meet the following:
 - 1. Smoke development: Less than 450 when tested in accord with NFPA 258.
 - 2. Critical radiant flux: Class II, 0.22 watt/cm² when tested in accord with ASTM E648-10. Carpet used in exit corridors is required to meet Class I, 0.45 watts/cm² critical radiant flux.
 - 3. Electrostatic propensity: Less than 3000 volts when tested in accord with AATCC 134.
 - 4. Flammability of carpet: Pass methanamine pill test when tested in accord with ASTM D2859-06.
 - 5. Emissions: Provide carpet/carpet tile that complies with testing and product requirements of CRI's "Green Label Plus" program.

1.5 DELIVERY, STORAGE AND HANDLING:

- A. Deliver materials in manufacturer's original mill wrappings, with carpet having register tag number attached. Deliver only after building is enclosed and spaces have controlled temperature and humidity.
- B. Store materials under cover, off floor, in ventilated space. Protect from damage, staining and moisture. Stand no roll material on end.

1.6 PROJECT/SITE CONDITIONS:

- A. Provide fresh air ventilation during entire installation process and for 72 hours afterwards.

1.7 WARRANTIES:

- A. Carpet tile warranty: Provide manufacturer's standard warranty for carpet tile stating that tile will remain dimensionally stable, colorfast and static-resistant and will not lose more than 15% by weight of face yarn, will not edge ravel or separate. Warranty period shall be 15 years, beginning at Date of Substantial Completion.

1.8 MAINTENANCE MATERIALS:

- A. Extra materials:
 - 1. Provide two cartons of each type, pattern and color of carpet tile for Owner's use.
 - 2. Store maintenance material where directed by Owner.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

- A. Carpet tile acceptable manufacturers; subject to compliance with specified requirements:
 - 1. Basis of design; Mohawk-Lees Group.
 - 2. Bentley.
- B. C-1 Basis of design; Mohawk-Lees Group.
 - 1. Collection: "Learn and Live" in color and patterns to be determined.
 - 2. Design:
 - a. Size: 24" x 24"
 - b. Surface Appearance: Level Heathered Loop
 - c. Fiber Type: Duracolor® Tricor Premium Nylon
 - d. Dye Method: Solution Dyed
 - 3. Performance:
 - a. Construction: Tufted
 - b. Gauge: 1/12" (47.00 rows per 10cm)
 - c. Stain Release Technology: Permanent, Built into the Fiber
 - d. GSA Stain Release Technology: Passes
 - e. Soil Release Technology: EcoSentry Soil Protection
 - f. Backing Material: EcoFlex NXT
 - g. Flammability: ASTM E 648 - Class 1 (Glue Down)
 - h. Smoke Density: ASTM E 662 - Less than 450
 - i. Static Propensity: AATCC - 134 Under 3.5 KV
 - 4. Installation Method: Quarter turn.

2.2 INSTALLATION ACCESSORIES:

- A. Carpet edge strip: Schlüter Systems, Inc., "Schiene", clear anodized aluminum in profiles selected by Architect from manufacturer's standard selections or as manufactured by EMAC.

- B. Trim and transition profiles:
 - 1. Basis of design is Schluter Systems L.P. Products of other manufacturers may be submitted for Architect's consideration, subject to compliance with specified requirements and Architect's approval.
 - 2. TS-6 Transition Strip: Schluter SCHIENE, anodized aluminum at carpet to porcelain tile, confirm depth with scheduled finishes.
- C. Adhesive: Water-resistant, mildew-resistant, non-staining type recommended by carpet and carpet tile manufacturer's product data for installation conditions. Adhesive shall be solvent-free, release type, allowing removal of carpet and carpet tile without damage to carpet, carpet tile, or substrate.
 - 1. Adhesive shall have a VOC content of 50 g/L or less.
- D. Leveling compound:
 - 1. Acceptable products:
 - a. Custom Building Products, LevelQuik RS.
 - b. H.B. Fuller Construction Products, TEC Level Set 200.
 - c. Mapei, Ultraplan 1 Plus.
 - 2. Characteristics: Fast-setting, self-leveling underlayment, minimum 28-day compressive strength of 4,000 psi.
 - 3. Provide primers for leveling compound as recommended or required by leveling compound manufacturer's product data.
- E. Miscellaneous materials: Furnish fiberglass seaming tape, thread and similar accessories required for carpet installation.

PART 3 - EXECUTION

3.1 PREPARATION:

- A. Subfloor curing:
 - 1. Concrete subfloors shall be cured in accord with the requirements of the Section 03 3000 - Cast-In-Place Concrete.
 - 2. If a curing compound has been used, Contractor shall verify that compound is compatible with flooring manufacturer's installation materials.
 - 3. If the curing compound is not compatible, or if compatibility is unknown, Contractor shall remove curing compound by shot-blasting or other methods approved by floor finish manufacturer.
- B. Concrete moisture vapor emission, humidity levels and pH testing: Perform one or more of the following tests, as required by flooring manufacturer's product data, using the following methods:
 - 1. Moisture vapor emissions: Perform tests on subfloors in accord with ASTM F1869-11 calcium chloride test and flooring manufacturer's product data, to determine if surfaces are acceptable to receive specified flooring products.
 - 2. Humidity level: Perform on subfloors in accord with ASTM F2170-11 *in situ* probe and flooring manufacturer's product data, to determine if surfaces are acceptable to receive specified flooring products.
 - 3. Concrete pH level: Perform on subfloors to verify that surfaces are acceptable to receive specified flooring products.
 - 4. Correction of conditions: Prior to installation, correct conditions that do not meet flooring manufacture's requirements, or that may be detrimental to flooring installation.
- C. Vacuum substrate immediately prior to beginning carpet installation. Remove debris, oil, grease and other foreign materials. Surfaces to receive installation shall be dry.
- D. Grind high areas and fill depressions with leveling compound where required to produce smooth installation and for proper alignment of carpet with adjacent flooring materials.

3.2 WORKMANSHIP:

- A. Except where more stringent requirements are specified herein, comply with manufacturer's product data and with CRI Commercial Installation Standard 104, Standard for Installation of Commercial Textile Floorcovering Materials.
- B. Lay carpet tile with pattern and texture running in direction as shown on the drawings and approved shop drawings, and as directed by the Architect.
- C. Extend carpet tile under movable furniture and equipment and into closets of rooms indicated to be carpeted unless other floor finish is indicated in finish schedule.
- D. Install carpet edge strip at locations where edge of carpet is exposed to traffic, except where another device, such as a threshold, is indicated.
- E. Maintain edges and seams straight and square with adjacent surfaces.

3.3 CARPET TILE INSTALLATION:

- A. Divide areas into grid pattern of maximum sizes recommended by manufacturer's product data. Center grid in each area, perpendicular to walls, but placed to avoid edge tiles of less than half tile size. Grids shall align continuously through door openings and visually adjacent areas.
- B. Adhesively install first row of tiles in both directions along grid centerlines. Adhesively install remaining infill tiles.
- C. Lay carpet tile with pattern and texture running in direction as shown on the drawings and approved shop drawings, and as directed by Architect. Locate perpendicular seams at doorways so as not to occur in doorways. Locate parallel seams at doorways directly under door.
- D. Accurately scribe and cut tile to abutting surfaces. Maximum clearance shall be 1/32".
- E. Use carpet tiles from only one side of "cut" and one single dye lot within each complete area, and align tiles with grain in one direction as indicated on backs of tiles.
- F. Lay tiles with tightly abutted joints and corners, joint lines consistently straight and parallel.
- G. Install carpet edge strip at locations where edge of carpet is exposed to traffic except where another device, such as a threshold, is indicated.

3.4 CLEANING AND PROTECTION:

- A. At completion of installation, remove debris. Sort out scraps to be saved.
- B. Vacuum carpet with a commercial type vacuum cleaner having a rotating agitator in nozzle. Use corner attachment for vacuuming in corners and crevices.
- C. Remove stains with spot remover acceptable to carpet manufacturer.
- D. Immediately after cleaning, cover carpeted areas with heavy kraft paper. Maintain in place for remainder of construction period.
- E. Just prior to Date of Substantial Completion, remove protective covering and vacuum carpet. Steam clean areas if required to remove stains.
- F. Replace carpet which cannot be cleaned.

END OF SECTION

SECTION 09 7813 - FIBERGLASS REINFORCED PLASTIC (FRP) WALL PANELS

PART 1 - GENERAL

1.1 SUMMARY:

- A. Section includes fiberglass reinforced plastic wall panels for back-of-house locations such as mop sink surrounds and other indicated locations.

1.2 ACTION SUBMITTALS:

- A. Shop drawings: Submit detailed shop and erection drawings for wall panels and related trim. Include dimensioned plans, elevations and sections. Indicate panels to be erected as part of job mock-up. Indicate relationship to adjacent work. Indicate allowance for thermal movement.
- B. Product data: Submit manufacturer's complete product and installation literature, marked as applicable to project. Include product performance characteristics and installation requirements.
- C. Samples: Submit sample of 1'-0" by 1'-0" size, minimum, indicating color, texture and general appearance of finished panels and 1'-0" long section of each trim type and finish.

1.3 INFORMATIONAL SUBMITTALS:

- A. Product Certificates: Signed by manufacturers certifying that the following products comply with requirements:
 - 1. Adhesives.
- B. Evaluation Reports: For fire-retardant-treated materials, from ICC-ES.

1.4 CLOSEOUT SUBMITTALS:

- A. Maintenance data: Submit as part of Closeout Procedures with copy included with product data submittal. Include instructions for cleaning, maintaining and replacing panels.

1.5 DELIVERY, STORAGE AND HANDLING:

- A. Deliver panels to project after spaces are ready for installation. Do not store materials at project site.
- B. Protect materials from damage, including deformation or staining. Reject damaged materials.

1.6 PROJECT/SITE CONDITIONS:

- A. Coordinate work of this section with interfacing work, including substrate construction to which panels are to be installed. Take field measurements to ascertain required panel measurements.
- B. Environmental requirements:
 - 1. Install materials only when normal temperature and humidity conditions approximate interior conditions that will exist when the space is occupied. Do not install at temperatures below 65°F.
 - 2. Remove materials from packaging and allow to acclimatize to installation area for 24 hours before application.
 - 3. Maintain constant minimum temperature of 65°F. in spaces for at least 48 hours before, during and 48 hours after application.

PART 2 - PRODUCTS

2.1 FRP WALL PANELS; FRP-1:

- A. Acceptable products; subject to compliance with specified requirements:
 - 1. FRP-1 Basis of design: Crane Composites, Inc., a Crane Co. Company, Crane Composites, "Glasbord-FSI Smooth with Surfaseal".
 - 2. Nudo Products, Inc., Fiber-Lite Liner Panels, LP-F9-FR.
 - 3. Marlite, Induro FRP with SaniSEAL.
- B. Characteristics:
 - 1. Material: Fiberglass reinforced plastic (FRP).
 - 2. Thickness: 0.090", minimum.
 - 3. Size: 4'-0" by 10'-0" to provide full height vertical installation without horizontal seams.
 - 4. Finish: Manufacturer's standard smooth surface on exposed side.
 - 5. Color: As selected by Architect from manufacturer's standard color series.
 - 6. Fire resistance rating: Class A when tested in accord with ASTM E94-04. Evidence of fire-resistance rating shall be clearly marked by embedded threads or markings on panel backs and faces; face threads or markings shall be discernible only under blacklight light source.

2.2 ACCESSORY PRODUCTS:

- A. Adhesives: Waterproof mastic and contact type adhesives in accord with panel manufacturer's product data for substrates involved.
 - 1. VOC Content: 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. Moldings for panel joints: Manufacturer's standard vinyl edge cap J-mold, H-mold divider, and both interior and exterior corner moldings; in color to match panel color.
- C. Sealant: One-part, mildew-resistant, silicone as specified in Section 07 9200 - Joint Sealants.
 - 1. VOC Content: 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.3 SOURCE QUALITY CONTROL:

- A. Allowable fabrication tolerances:
 - 1. Finished panel sizes: $\pm 1/16$ " in individual panel width or length.
 - 2. Squareness: $\pm 1/8$ " in diagonal measurement.
 - 3. Location of cutouts: $\pm 1/8$ ".

PART 3 - EXECUTION

3.1 PREPARATION:

- A. Prime or seal sub-surfaces to receive panels using materials recommended by panel and adhesive manufacturers' product data.
- B. Examine substrate conditions to verify that backer boards, grounds, anchors, accessories, door frames, electrical and mechanical work in or behind wall panels has been installed prior to proceeding with installation of wall panels.

3.2 INSTALLATION:

- A. Install FRP panels in locations indicated on drawings.

- B. Install panels in full size sheets with minimum joints. Joint locations shall be indicated on approved shop drawings.
- C. Cut, drill and form panels in accord with manufacturer's fabrication instructions. Edges shall be straight, smooth and square without chips, spalls, burns or imperfections.
- D. Install wall panels vertically in full height sections in accord with approved product data and within allowable tolerances.
 - 1. Install using adhesive method, providing full coverage, without voids, in addition to edge trim.
 - 2. Allow minimum 1/16" space between edge of panel and bottom of trim or other abutting materials for panel expansion.
- E. Coordinate installation with adjacent and interfacing surfaces. Align grain pattern with adjacent panels.
- F. Provide edge molding at joints, exposed edges and corners.
 - 1. Seal back face of panel to molding leg, but do not allow sealant to enter edge expansion space. Seal using silicone bath sealant specified in Section 07 9200 - Joint Sealants.
 - 2. Adhere joint and edge trim using mastic in accord with panel manufacturer's product data.
 - 3. Space edge trim 1/4" from abutting material and seal edge trim to adjacent abutting material using mildew-resistant silicone bath sealant as specified in Section 07 9200 - Joint Sealants.
- G. Wall panels shall cover exposed interior wall surfaces not indicated to receive another finish. Install panels prior to installation of electrical cover plates and other miscellaneous surface mounted elements.

3.3 FIELD QUALITY CONTROL:

- A. Allowable erection tolerances:
 - 1. Variation from plumb: 1/16" in total panel height.
 - 2. Variation from level: 1/8" in 10'-0", non-cumulative.
 - 3. Variation in face alignment of adjacent panels: 1/32".

3.4 CLEANING:

- A. Just prior to Date of Substantial Completion, clean panel surfaces of soil and discolorations. Soiling that results in permanent discoloration will be cause for rejection of materials on which it occurs.
- B. Replace panels which have become damaged or permanently stained.

END OF SECTION

SECTION 09 9100 - PAINTING AND COATING

PART 1 - GENERAL

1.1 SUMMARY:

- A. Work of this section includes:
 - 1. Touching up of shop-applied prime coats.
 - 2. Preparation of surfaces to receive finishes.
 - 3. Painting, staining or otherwise finishing of surfaces, except as otherwise indicated.
 - 4. Priming, back priming and finishing of interior finish carpentry.
- B. Related work specified elsewhere:
 - 1. Shop-applied primer coats.
 - 2. Joint sealants.
 - 3. Wall coverings.
 - 4. Special finishes.
 - 5. Piping identification.
 - 6. Prefinished items.

1.2 DEFINITIONS:

- A. Properly painted surface: The painting contractor shall produce properly painted surfaces as herein defined, and shall obtain Architect's approval of all surfaces.
 - 1. A "properly painted surface" is defined as uniform in appearance, color, texture, hiding and sheen.
 - 2. Surfaces shall be free of foreign material, lumps, skins, runs, sags, holidays, misses, or insufficient coverage.
 - 3. Surfaces shall be free of drips, spatters, spills or overspray caused by the painting contractor's workforce.
 - 4. To determine whether a surface has been "properly painted", the surface shall be examined without magnification at a distance of thirty-nine (39) inches or one (1) meter, or more, under finished lighting conditions and from a normal viewing position.
- B. Standard coating terms: As defined in ASTM D16-14.
- C. Commercial: Painter grade products.
- D. DFT: Dry film thickness of the coating.
- E. Premium: Best quality product (top of the line):
- F. VOC: Volatile Organic Compounds found in primers, paints, sealers and stains. VOC levels are designated in grams per liter (g/L).

1.3 PERFORMANCE REQUIREMENTS:

- A. DFT for each primer, paint, sealer and stain shall be as recommended by product manufacturer's product data.
- B. VOC Content: For field applications that are inside the weatherproofing system, paints and coatings shall comply with VOC content limits of authorities having jurisdiction and the following VOC content limits:
 - 1. Flat paints and coatings: 50 g/L.
 - 2. Nonflat paints and coatings: 150 g/L.

3. Dry-fog coatings: 400 g/L.
4. Primers, sealers, and undercoaters: 200 g/L.
5. Anticorrosive and antirust paints applied to ferrous metals: 250 g/L.
6. Zinc-rich industrial maintenance primers: 340 g/L.
7. Pretreatment wash primers: 420 g/L.
8. Shellacs, clear: 730 g/L.
9. Shellacs, pigmented: 550 g/L.

1.4 ACTION SUBMITTALS:

- A. Product data:
 1. Submit complete list of products proposed for use at least 30 days prior to commencement of painting work.
 2. Indicate manufacturer, brand name, quality, type, and sheen for each type of paint and for each surface to be finished. Indicate ** VOC rating and ** compliance with applicable regulations.
 3. Indicate manufacturer's instructions regarding mixing, surface preparation and application. Include application rates, film thickness and required primers.
 4. Intent of Contractor to use products specified does not relieve him from responsibility of submitting product list.
- B. Color samples: Submit two sets of color samples from paint manufacturers proposed for use, for color selections by Architect.
- C. Substrate brush-outs:
 1. In addition to color coat brush-outs, submit one actual brush-out sample application for each paint type, color and sheen as applicable to the following substrates.
 2. Apply complete finish system in the number of coats specified, to the actual substrate material or simulated material indicated; allow 1" offset of each successive coat along one edge to illustrate successive applications.
 - a. Concrete unit masonry: One face of a concrete block of type and texture used on the project.
 - b. Textured stucco: 1'-0" by 1'-0" sample of stucco with textured paint finish.
 - c. Gypsum board, concrete: Apply over gypsum board, 1'-0" by 1'-0" size, edges taped and sanded.
 - d. Metals: Apply over hardboard, 1'-0" by 1'-0" size.
 - e. Painted wood: Wood stock typical of type, color and cut used on the project, minimum 6" wide by 1'-0" long.

1.5 QUALITY ASSURANCE:

- A. Applicable standards:
 1. American Coatings Association (ACA), Gloss Standard.
 2. ASTM International (ASTM), as referenced herein.
 3. American National Standards Institute (ANSI) Performance Standards.
 4. Environmental Protection Agency (EPA), volatile organic compounds (VOC) standards as required by local codes and regulations.
 5. Master Paint Institute (MPI) established paint categories and standards.
 6. Occupational Safety & Health Act (OSHA) Safety Standards.
 7. Ozone Transmission Commission (OTC) established levels of Volatile Organic Compounds.
 8. Paint Decorating Contractors of America (PDCA) Application Standard, P1 Standard and P5 Standard.

1.6 DELIVERY, STORAGE AND HANDLING:

- A. Delivery: Deliver materials to project site ready-mixed in original containers with labels intact; labels bearing manufacturer's name, paint type, color and recommended installation and reducing procedures.
- B. Storage and handling:
 - 1. Store materials in location acceptable to Architect.
 - 2. Coating materials and thinners stored on site shall be kept in a clean, secure and climate controlled area.
 - 3. Labels shall remain on containers used to hold primers, paints or stains while on site. Containers without labels shall be disposed of.
 - 4. Product name, number, health and safety information, and precautions shall be legible at all times during storage and use.
 - 5. Close containers at end of day's work. Leave no materials open.
- C. Waste management and disposal:
 - 1. Disposal containers for recycled materials must be established on site.
 - 2. Dispose of rags containing solvent, daily.
 - 3. Dispose of hazardous coatings in accord with state, county and local regulations for hazardous waste disposal.

1.7 PROJECT/SITE CONDITIONS:

- A. Environmental requirements:
 - 1. Comply with manufacturer's product data as to environmental conditions under which materials may be applied.
 - 2. Apply no materials in spaces where dust is being generated.
 - 3. Comply with applicable VOC regulations.
- B. Protection: Cover finished work of other trades and surfaces not being painted concurrently and prefinished items.
- C. Safety precautions:
 - 1. Provide temporary fire protection equipment in materials storage area.
 - 2. Prohibit smoking in storage area.

1.8 MAINTENANCE:

- A. Extra materials:
 - 1. Provide one gallon of each type and color of paint and stain in full unused cans.
 - 2. Cans shall be marked with color name, number and type of paint and stain.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

- A. Acceptable manufacturers: Except as otherwise noted, products specified as a standard of quality are manufactured by Sherwin Williams. Products of the following manufacturers similar in type and quality are acceptable for use, subject to approval of product list:
 - 1. PPG Paints.
 - 2. Benjamin Moore Co.
- B. Where products other than those of the manufacturer listed as the standard of quality are specified in Painting Schedule, such products have been selected to achieve specific results and substitutions will be allowed only in accord with Section 01 2500 - Substitution Procedures.

2.2 PAINTING MATERIALS:

- A. Miscellaneous materials:
 - 1. Paint thinners and tints shall be products of same manufacturer as paints or approved by him for use with his products.
 - 2. Shellac, turpentine, patching compounds and similar materials required for execution of work shall be pure, best quality products.
- B. Paint and stain colors will be selected by Architect from manufacturer's standard color range with final approval based on brush-out submittal.

PART 3 - EXECUTION

3.1 PREPARATION:

- A. Surfaces to receive finishes shall be dry and free of debris, oils, dust or other deleterious materials.
- B. Existing surfaces:
 - 1. For previously painted surfaces, remove dirt, debris and chalk by washing with detergent and water. Sand glossy surfaces. Remove loose paint and blisters by scraping and sanding. Apply bond coat when required by paint manufacturer's product data.
 - 2. Previously painted metal surfaces to remain shall be wire-brushed and cleaned of existing paint and rust.
 - 3. Treat mildewed surfaces with a solution of one quart hypochlorite bleach to a half cup of detergent to one gallon water. Rinse and allow to dry prior to painting.
 - 4. Previously painted masonry:
 - a. Where existing paint is loose or blistered, remove by scraping or brushing.
 - b. Remove debris and chalking from surfaces by washing with detergent and water. Flush with clean water. Touch up with material specified for finish.
- C. Where finish materials abut or are abutted by dissimilar materials, caulk joints in accord with Section 07 9200 - Joint Sealants.
- D. Lumber, plywood and veneered wood surfaces:
 - 1. Apply shellac, maximum two pounds cut to knots, pitch and resinous sapwood prior to application of first paint or stain coat.
 - 2. For surfaces to receive opaque finish, fill nail holes, cracks, joints and defects with spackling compound. Apply after first coat of paint.
 - 3. For surfaces to receive transparent finish, fill nail holes, cracks and defects with wood filler matching finish color.
 - 4. Sand surfaces smooth except where rough sawn surfaces are indicated. Final step shall remove scuffs, handling marks and effects of moisture exposure. Dust to remove debris.
 - a. Sand plane surfaces using sanding block; touch sand moldings in manner preventing removal of sharp edges or obscuring profile.
 - b. Moldings cut with machine finish or minimum 16 knife cuts per inch shall not require further sanding except to correct irregularities.
 - c. Sand surfaces within normal visual range, including surfaces within 10'-0" of floor level, using not less than 80 grit abrasive exterior or 100 grit abrasive interior, except increase to 120 to 180 grit abrasive for transparent finished interior surfaces.

- E. Gypsum board:
 - 1. Fill narrow, shallow cracks and small holes with patching compound. Allow to dry and sand smooth without raising nap of gypsum board paper.
 - 2. Gypsum board shall be finished as specified in Section 09 2900 - Gypsum Board prior to painting.
- F. Concrete:
 - 1. Fill cracks, holes and irregularities with cement grout.
 - 2. Remove laitance, oil, grease, dirt and debris from surfaces. Allow concrete to cure prior to paint application.
- G. Concrete unit masonry: Rub to remove loose mortar and debris. Fill irregularities with cement grout.
- H. Galvanized metals:
 - 1. Test for passivator or stabilizer using copper sulfate solution (20 grams of copper sulfate in one liter of water). If passivator or stabilizer is present, remove by brush blasting, sanding or chemical etching.
 - 2. Wash with xylol to remove grease, oil and contaminants. Wipe dry with clean cloth.
- I. Aluminum:
 - 1. Sand or scrape to remove oxides.
 - 2. Wash with xylol to remove grease, oil and contaminants. Wipe dry with clean cloth.
- J. Ferrous metals:
 - 1. Wire-brush or sandpaper to remove rust and mill scale.
 - 2. Solvent-clean with xylol to remove grease, oil and contaminants. Wipe dry with clean cloth.

3.2 APPLICATION:

- A. Apply paint only when moisture content of surfaces is within limits recommended in product data. Apply paint materials using clean brushes, rollers or spraying equipment.
- B. Apply materials at rate not exceeding that recommended in product data for surface being painted, less ten percent for losses.
- C. Comply with product data for drying time between coats.
- D. Sand and dust between coats to remove defects visible from a distance of 5'-0".
- E. Finish coats shall be smooth, free of brush marks, streaks, laps or pile-up of paint, skipped or missed areas. Do not apply additional coats until completed coat has been observed by Architect. Only these coats of paint will be considered in determining number of coats applied.
- F. Make edges of paint adjoining other materials or colors clean and sharp without overlapping.
- G. Primer coats may be omitted for surfaces specified to receive factory-applied primer, if primer is compatible with finish coats. If primer coats are not compatible, substitute a bond coat as recommended by paint manufacturer for specified primer coat.
- H. Where two-coat finish is specified, prime coat shall be tinted to approximate finish color.

- I. Where portion of finish on gypsum board partition is damaged or unacceptable, refinish entire surface of partition.
- J. Seal tops and bottoms of interior doors with prime coat only; side edges same as faces.
- K. Finish top, bottom and side edges of exterior doors same as faces.
- L. Paint inside of ductwork flat black for entire area visible through ceiling openings. Paint underside of ductwork and other above-ceiling items flat black for entire area visible through ceiling openings.
- M. Paint exposed piping and ductwork in painted spaces same as adjacent wall surfaces.
- N. Paint exposed grilles and registers in public spaces.
- O. Paint walls, exposed structure, handrails and exposed ductwork and piping in stairwells.
- P. Remove and protect hardware, accessories, device plates, lighting fixtures, factory-finished work and similar items, or provide in-place protection. Upon completion of each space, replace removed items.
- Q. Unless otherwise indicated, paint exposed structural system.
- R. Back prime interior finish carpentry with material specified for prime coat, without runs on face. Finish cut edges prior to installation.
- S. Unless otherwise indicated, paint construction on roof top, including prefinished mechanical and electrical equipment.
- T. Unless otherwise indicated, paint ground mounted mechanical, plumbing and electrical equipment, including prefinished equipment.
- U. The following surfaces do not require painting:
 - 1. Face brick.
 - 2. Architectural precast concrete.
 - 3. Prefinished and factory-finished surfaces and items, except where indicated otherwise.
 - 5. Concealed ductwork, conduit and piping.

3.3 PAINT SCHEDULE/FORMULAE:

- A. Sheens, and locations of sheens, will be indicated on drawings.
- B. Exterior surfaces; number of coats specified are minimum:
 - 1. Concrete: Provide the following finish systems over exterior concrete and masonry substrates:
 - a. Flat Acrylic Finish:
 - 1) First coat: SW Loxon Masonry Primer, A24W300 (<100 g/l voc).
 - 2) Second coat: SW A-100 Exterior Latex Flat, A6 Series (<50 g/l voc).
 - 3) Third coat: SW A-100 Exterior Latex Flat, A6 Series (<50 g/l Voc).
 - b. Low-Luster Acrylic Finish:
 - 1) First coat: SW Loxon Masonry Primer, A24W300 (<100 g/l voc).
 - 2) Second coat: SW A-100 Exterior Latex Satin, A-82 Series, (<50 g/l voc).
 - 3) Third coat: SW A-100 Exterior Latex Satin, A-82 Series, (<50 g/l voc).

2. Ferrous Metal: Provide the following finish systems over exterior ferrous metal. First coat: is not required on shop-primed items. Low-Luster Acrylic Finish:
 - a. First coat: SW Pro Industrial Pro-Cryl Universal Metal Primer, B66-310 (<100 g/l voc).
 - b. Second coat: SW SW Pro Industrial Acrylic Eg-Shel, B66-660 Series (0 g/l voc).
 - c. Third coat: SW Pro Industrial Acrylic Eg-Shel, B66-660 Series (0 g/l voc).
 3. Zinc-Coated Metal: Provide the following finish systems over exterior zinc-coated metal surfaces:
 - a. Low-Luster Acrylic Finish:
 - 1) First coat: SW Pro Industrial Pro-Cryl Universal Metal Primer, B66-310 (<100 g/l voc).
 - 2) Second coat: SW Pro Industrial Acrylic Eg-Shel, B66-660 Series (0 g/l voc).
 - 3) Third coat: SW Pro Industrial Acrylic Eg-Shel, B66-660 Series (0 g/l voc).
 - b. Semi-gloss Acrylic-Enamel Finish:
 - 1) First coat: SW Pro Industrial Pro-Cryl Universal Metal Primer, B66-310 (<100 g/l voc).
 - 2) Second coat: SW A-100 Exterior Latex Gloss, A8 Series, (<50 g/l voc).
 - 3) Third coat: SW A-100 Exterior Latex Gloss, A8 Series, (<50 g/l voc).
 4. Aluminum: Provide the following finish systems over exterior aluminum surfaces, except factory-applied fluoropolymer finished aluminum:
 - a. Low-Luster Acrylic Finish:
 - 1) First coat: SW Pro Industrial Pro-Cryl Universal Metal Primer, B66-310 (<100 g/l voc)
 - 2) Second coat: SW Pro Industrial Acrylic Eg-Shel, B66-660 Series (0 g/l voc).
 - 3) Third coat: SW Pro Industrial Acrylic Eg-Shel, B66-660 Series (0 g/l voc).
 - b. Semi-gloss Acrylic-Enamel Finish:
 - 1) First coat: SW Pro Industrial Pro-Cryl Universal Metal Primer, B66-310 (<100 g/l voc).
 - 2) Second coat: SW A-100 Exterior Latex Gloss, A8 Series, (<50 g/l voc).
 - 3) Third coat: SW A-100 Exterior Latex Gloss, A8 Series, (<50 g/l voc).
- C. Interior surfaces paint schedule:
1. Concrete: Provide the following paint systems over interior concrete masonry substrates:
 - a. Flat Acrylic Finish:
 - 1) First coat: SW Harmony Low Odor Interior Latex Primer, B11 Series, (0 g/l voc).
 - 2) Second coat: SW Harmony Low Odor Interior Latex Flat, B5 Series, (0 g/l voc).
 - 3) Third coat: SW Harmony Low Odor Interior Latex Flat, B5 Series, (0 g/l voc).
 - b. Semi-gloss Acrylic-Enamel Finish:
 - 1) First coat: SW Loxon Masonry Primer, A24W8300 (<100 g/l voc).
 - 2) Second coat: SW ProMar 200 Zero VOC S/9, B31-2600, (<0 g/l voc).
 - 3) Third coat: SW ProMar 200 Zero VOC S/9, B31-2600, (<0 g/l voc).

2. Concrete Masonry Unit: Provide the following finish systems over interior concrete masonry:
 - a. Flat Acrylic Finish:
 - 1) First coat: SW PrepRite Interior/Exterior Block Filler, B25W25 (<50 g/l voc).
 - 2) Second coat: SW ProMar 200 Zero VOC Interior Latex Flat, B30-2600 (0 g/L voc).
 - 3) Third coat: SW ProMar 200 Zero VOC Interior Latex Flat, B30-2600 (0 g/L voc).
 - b. Semi-gloss Acrylic-Enamel Finish:
 - 1) First coat: SW PrepRite Interior/Exterior Block Filler, B25W25 (<50 g/l voc).
 - 2) Second coat: SW ProMar 200 Interior Zero VOC Latex S/G Enamel, B31-2600 Series, (<0 g/l voc).
 - 3) Third coat: SW ProMar 200 Interior Zero VOC Latex S/G Enamel, B31-2600 Series, (<0 g/l voc).
3. Gypsum Board: Provide the following finish systems over interior gypsum board surfaces:
 - a. Flat Acrylic Finish:
 - 1) First coat: SW Harmony Low Odor Interior Latex Primer, B11 Series, (0 g/l voc).
 - 2) Second coat: SW Harmony Low Odor Interior Latex Flat, B5 Series, (0 g/l voc).
 - 3) Third coat: SW Harmony Low Odor Interior Latex Flat, B5 Series, (0 g/l voc).
 - b. Low-Luster Acrylic Finish:
 - 1) First coat: SW Harmony Low Odor Interior Latex Primer, B11 Series, (0 g/l voc).
 - 2) Second coat: SW Harmony Low Odor Latex EgShel, B9 Series (0 g/l voc).
 - 3) Third coat: SW Harmony Low Odor Latex EgShel, B9 Series (0 g/l voc).
 - c. Semi-gloss Acrylic-Enamel Finish:
 - 1) First coat: SW Harmony Low Odor Interior Latex Primer, B11 Series, (0 g/l voc).
 - 2) Second coat: SW Harmony Low Odor Latex S/G Enamel, B10 Series, (0 g/l voc).
 - 3) Third coat: SW Harmony Low Odor Latex S/G Enamel, B10 Series, (0 g/l voc).
4. Wood and Hardboard: Provide the following paint finish systems over new interior wood surfaces:
 - a. Semi-gloss Acrylic-Enamel Finish:
 - 1) First coat: SW Harmony Low Odor Interior Latex Primer, B11 Series, (0 g/l voc).
 - 2) Second coat: SW Harmony Low Odor Latex S/G Enamel, B10 Series, (0 g/l voc).
 - 3) Third coat: SW Harmony Low Odor Latex S/G Enamel, B10 Series, (0 g/l voc).
 - b. Full-Gloss Acrylic-Enamel Finish:
 - 1) First coat: SW PrepRite Pro-Block Latex First coat:/Sealer, B51 Series (<100 g/l voc).
 - 2) Second coat: SW Pro Industrial Zero VOC Acrylic Gloss, B66-600 Series, (0 g/l voc).
 - 3) Third coat: SW Pro Industrial Zero VOC Acrylic Gloss, B66-600 Series, (0 g/l voc).

5. Plywood wall panels at IDF/MDF rooms and other indicated locations must have fire rated stamp visible on panels. Fire Marshall's Office to inspect panels and approve prior to receiving following Intumescent Fire Retardant Paint, UL Certified Class "A" Rating per ASTM E84 10-Minute Test and 30 Minute Rating per ASTM E84 Extended Test. Intumescent Fire Retardant Paint; Flat finish:
 - a. First and Second coat: Flame Control Coatings, LLC; FLAME CONTROL NO. 20-20A A Low VOC Water Base, Flat Latex Intumescent Fire Retardant Paint; applied in two coats at 155 sq. ft./U.S. gal. (3.8 m²/L) each.
6. Ferrous Metal: Provide the following finish systems over ferrous metal; low-luster acrylic finish:
 - a. First coat: SW Pro Industrial Pro-Cryl Universal Metal Primer, B66-310 (<100 g/l voc).
 - b. Second coat: SW Pro Industrial Acrylic Eg-Shel, B66-660 Series (0 g/l voc).
 - c. Third coat: SW Pro Industrial Acrylic Eg-Shel, B66-660 Series (0 g/l voc).
7. Zinc-Coated Metal: Provide the following finish systems over interior zinc-coated metal surfaces:
 - a. Low-Luster Acrylic Finish:
 - 1) First coat: SW Pro Industrial Pro-Cryl Universal Metal Primer, B66-310 (<100 g/l voc).
 - 2) Second coat: SW Pro Industrial Acrylic Eg-Shel, B66-660 Series (0 g/l voc).
 - 3) Third coat: SW Pro Industrial Acrylic Eg-Shel, B66-660 Series (0 g/l voc).
 - b. Semi-gloss Acrylic-Enamel Finish:
 - 1) First coat: SW Pro Industrial Pro-Cryl Universal Metal Primer, B66-310 (<100 g/l voc).
 - 2) Second coat: SW ProMar 200 Zero VOC Interior Latex S/G Enamel, B31W2600 Series, (< 0 g/l voc).
 - 3) Third coat: SW ProMar 200 Zero VOC Interior Latex S/G Enamel, B31W2600 Series, (< 0 g/l voc).
8. Aluminum: Provide the following finish systems over interior aluminum surfaces; matching adjacent surfaces:
 - a. Low-Luster Acrylic Finish:
 - 1) First coat: SW Pro Industrial Pro-Cryl Universal Metal Primer, B66-310 (<100 g/l voc).
 - 2) Second coat: SW Pro Industrial Acrylic Eg-Shel, B66-660 Series (0 g/l voc).
 - 3) Third coat: SW Pro Industrial Acrylic Eg-Shel, B66-660 Series (0 g/l voc).
 - b. Semi-gloss Acrylic-Enamel Finish:
 - 1) First coat: SW Pro Industrial Pro-Cryl Universal Metal Primer, B66-310 (<100 g/l voc).
 - 2) Second coat: SW ProMar 200 Zero VOC Interior Latex S/G, B31-2600 Series, (0 g/l voc).
 - 3) Third coat: SW ProMar 200 Zero VOC Interior Latex S/G, B31-2600 Series, (0 g/l voc).

END OF SECTION

SECTION 10 1110 - VISUAL DISPLAY SURFACES

PART 1 - GENERAL

1.1 SUBMITTALS:

- A. Product data: Submit manufacturer's catalog cuts and installation instructions. Indicate the following:
 - 1. Sizes of markerboards.
 - 2. Materials and construction.
 - 3. Details of methods of installation and anchorage.

1.2 DELIVERY, STORAGE AND HANDLING:

- A. Deliver no materials until finishing operations are completed and spaces are ready for markerboard installation.

PART 2 - PRODUCTS

2.1 WC-1; MARKERBOARDS:

- A. Markerboards Acceptable manufacturers; subject to compliance with specified requirements:
 - 1. Basis of design: Claridge Products and Equipment, Inc., 800 Series, LCS 1 Markerboards.
 - 2. AARCO Products, Inc.
 - 3. Aywon, Reddi-Frame.
 - 4. Marsh, Inc.
 - 5. PolyVision Corp.
- B. WC-1; Markerboard Characteristics:
 - 1. Construction: Porcelain enameled steel bonded to particleboard with aluminum backing sheet with continuous frame/trim around perimeter.
 - 2. Materials:
 - a. Porcelain enameled steel: LCS 1; Minimum 24 ga.
 - b. Particleboard: ANSI A208.1, Grade 1-M-1, 3/8" thickness, made with binder containing no urea formaldehyde.
 - c. Backing sheet: Minimum 0.005 aluminum.
 - d. Frame/trim: Satin anodized extruded aluminum, 5/8" face, mitered.
 - 3. Marker trough: Extruded aluminum, tubular construction integral with bottom trim; full length, furnish with end closures.
 - a. Display/map rail: Extruded aluminum rail with cork insert, 2" width.
 - b. Map hooks: Spring clip type map hooks; four per unit mounted on display/map rail.
 - c. Marker trough: Extruded aluminum, tubular construction integral with bottom trim; furnish with end closures.
 - d. Flag holder: Aluminum mounting clip with attached tube to receive flag staff; one per unit mounted on display/map rail.
 - 4. Sizes: As indicated on drawings. Furnish in one section.
 - 5. Color: Match Claridge #100 LCS White.
 - 6. Fasteners: Manufacturer's standard concealed mounting clips.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. Install markerboards at locations indicated on the drawings, in accord with manufacturer's product data.
 - 1. Attach markerboards using manufacturer's standard eyelets.
 - 2. Mount at heights indicated.
- B. Installation of all items shall be plumb, level and true to line within 1/8" in 12'-0".

END OF SECTION

SECTION 10 1450 - EXTERIOR SIGNAGE

PART 1 - GENERAL

1.1 SUMMARY:

- A. This Section includes, but is not necessarily limited to, exterior signage and dimensional letters and numbers.

1.2 ACTION SUBMITTALS:

- A. Product data: Submit for each type of sign specified, including details of construction relative to materials, dimensions of individual components, profiles, and finishes.
- B. Shop drawings: Shop drawings showing fabrication and erection of signs. Include plans, elevations, and large-scale sections of typical members and other components. Show anchors, grounds, layout, reinforcement, accessories, and installation details.
 - 1. For signs supported by or anchored to permanent construction, provide setting drawings, templates, and directions for installation of anchor bolts and other anchors to be installed as a unit of Work in other Sections.
 - 2. Templates: Furnish full-size spacing templates for individually mounted dimensional letters and numbers.
 - 3. Indicate provisions for thermal expansion and contraction of materials.
 - 4. Include templates required for locations of anchors installed by others.
- C. Samples: Provide following samples of each sign component for initial selection of color, pattern and surface texture as required and for verification of compliance with requirements indicated.
 - 1. Dimensional Letters: Provide full-size representative samples of each dimensional letter type required, showing letter style, color, and material finish and method of attachment.
- D. Delegate-design submittal for dimensional letters and exterior signage: Submit calculations for loadings and stresses of all framing, panels and anchors, for exterior signs over 4'-0" high, under Professional Engineer's seal who is experienced in design of this Work and licensed in the State of Texas.

1.3 INFORMATIONAL SUBMITTALS:

- A. Qualification Data: Submit qualification data for firms and persons specified in Quality Assurance Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names of architects and owners, and other information specified.

1.4 QUALITY ASSURANCE:

- A. Applicable standards:
 - 1. Aluminum Association (AA), standards as referenced herein.
 - 2. American Iron and Steel Institute (AISI).
 - 3. Americans with Disabilities Act (ADA).
 - 4. Texas Department of Licensing and Regulations, the Elimination of Architectural Barriers Act (TAS).
- B. Manufacturer Qualifications: Provide Work required under this Section from manufacturer regularly engaged in Work of this magnitude and scope for minimum of five years.

- C. Sole Source Responsibility: For each separate type of sign required, obtain sign from a single source with resources to produce products of consistent quality in appearance and physical properties without delaying the work.

1.5 PERFORMANCE REQUIREMENTS:

- A. Wind loading: Design exterior signs to withstand positive and negative wind loads as calculated in accordance with International Building Code, 2015 Edition.
 - 1. Wind load:
 - a. Velocity (ULT): 144 MPH, Three second gust
 - b. Exposure: C
 - c. Risk Category: IV
 - 2. Safety Factor: 1.15 times design wind load.
 - 3. Design, construct and install structural and non-structural support framing in conformance with applicable building code and with AISI Standards.
 - 4. Design to provide for movement of components without damage, undue stress on fasteners, or other detrimental effects when subject to seasonal or cyclic day/night temperature ranges.
 - 5. Design system to accommodate construction tolerances, deflection of building structural members, and clearances of intended openings.
- B. Thermal movement: Design, fabricate and install component parts to provide for expansion and contraction over a temperature range for material of 150° F., without buckling, sealant joint failure, glass breakage, undue stress on members or anchors, and other detrimental effects.
- C. Flatness of panels: Panels shall have no visual distortion when viewed in installed position. All panel faces shall be of such flatness that when measured, maximum slope of surface at any point, measured from nominal plane of surface, shall not exceed 1.0%. All panels not meeting these requirements are subject to rejection by Architect.

1.6 PROJECT CONDITIONS:

- A. Field Measurements: Take field measurements prior to fabrication of the work and preparation of shop drawings, to ensure proper fitting of the work. Show recorded measurements on final shop drawings. Notify the Owner and the Architect, in writing, of any dimensions found which are not within specified dimensions and tolerances in the Contract Documents, prior to proceeding with the fabrication. Coordinate fabrication schedule with construction progress to avoid delaying the work.

1.7 DELIVERY, STORAGE AND HANDLING:

- A. Deliver signs for interior installation only after building is enclosed and designated areas are ready to receive work.
- B. Cover or otherwise protect finished surfaces from damage or stains for remainder of work.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

- A. Acceptable manufacturers: Include, but are not necessarily limited to following, subject to compliance with specified requirements:
 - 1. ASI Sign Systems.

2. A.R.K. Ramos Signage Systems.
3. Gemini, Inc.
4. Innerface Sign Systems, Inc.
5. Southwell Co.

2.2 MATERIALS:

- A. Aluminum Sheet and Plate: Provide aluminum sheet of alloy and temper recommended by the sign manufacturer for the type of use and finish indicated, and with not less than the strength and durability properties specified in ASTM B209-07.
 1. Finish: As indicated on drawings.
- B. Aluminum Extrusions: Provide aluminum extrusions of alloy and temper recommended by the sign manufacturer for the type of use and finish indicated, and with not less than the strength and durability properties specified in ASTM B221-08 for 6063-T5 and 6063-T6.
 1. Post Shapes: In size and shape indicated on drawings and as required to meet structural calculations.
- C. Stainless steel:
- D. Fasteners: Use concealed fasteners fabricated from metals that are not corrosive to the sign material and mounting surface.
- E. Anchors and Inserts: Use nonferrous metal or hot-dipped galvanized anchors and inserts for exterior installations and elsewhere as required for corrosion resistance. Use toothed steel or lead expansion bolt devices for drilled-in-place anchors. Furnish inserts, as required, to be set into concrete or natural thin-veneer stone masonry work.
- F. Concrete: As detailed in drawings and specified in Section 03 3000 - Cast-In-Place Concrete.
- G. Bituminous coating for separation of dissimilar materials: Cold-applied asphalt emulsion complying with ASTM D1187-97(2011); minimum 15 mils dft.
- H. Posts: Galvanized steel pipe fabricated from ASTM A53, Type S, Grade B, continuously welded, ground and filed smooth, buffed out with all pipe scale removed or steel tube complying with ASTM A513.

2.3 DIMENSIONAL STAINLESS STEEL LETTERS:

- A. Characteristics: Standard letters; style, configuration, type, size and depth as indicated on drawings and to be visible from the street. Hold letters off face of stainless steel mounting tube distance indicated on drawings, minimum 1/4", using non-corrosive, permanent spacers. Anchor stainless steel mounting tube back to steel studs. All fasteners shall be concealed in the finished work. Finish and size as indicated on Drawings.
 1. Finish: #4 Satin Finish.
- B. Cast Letters: Form individual letters and numbers by casting. Produce characters with smooth, flat faces, sharp corners, and precisely formed lines and profiles, free from pits, scale, sand holes, or other defects. Cast lugs into the back of characters and tap to receive threaded mounting studs. Comply with requirements indicated for finish, style, and size.
 1. Metal: Stainless steel.

- C. Cutout Letters and Numbers: Cut letters and numbers from solid plate material of thickness indicated. Produce precisely cut characters with square cut, smooth edges. Comply with requirements indicated for finish, style, and size.
 - 1. Metal: AISI Type 302/304 stainless steel.

2.4 POST MOUNTED HANDICAPPED PARKING SIGN:

- A. Acceptable manufacturers:
 - 1. Emed Co., Inc.
 - 2. Seton Name Plate Co.
- B. Characteristics:
 - 1. Substrate: Hot dip galvanized bonderized 18 gauge steel.
 - 2. Finish: Baked enamel finish with white embossed borders; legends and symbols contrasting with bright blue background.
 - 3. Mounting: Rounded corners with two mounting holes.
 - 4. Accessibility ("Handicapped Parking") signs with lettering and graphics shall comply with local codes.
 - 5. Provide galvanized steel sign mounting hardware as instructed by manufacturer. Provide concrete footings of 3,000 psi compressive strength at 28 days, unless noted or directed otherwise.

PART 3 - EXECUTION

3.1 EXAMINATION AND PREPARATION:

- A. Examine substrates, areas, and conditions under which architectural graphic items are to be installed. Do not proceed with Work until unsatisfactory conditions detrimental to timely and proper completion of Work have been corrected.
- B. Verify that items, including anchor inserts, and electrical power are sized and located to accommodate signs.
 - 1. Inserts and Anchorages: Furnish inserts and anchoring devices which must be set in concrete or built into masonry for installation of this Work. Provide setting Drawings, templates, instructions and directions for installation of anchorage devices. Coordinate delivery with other work to avoid delay.
- C. Coordinate setting Drawings, diagrams, templates, instructions and directions for installation of items having integral anchors which are to be embedded in concrete or masonry construction. Coordinate delivery of such items to applicable trades for installation.
- D. Shop Assembly: Preassemble items in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for assembly and coordinated installation in the field.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION:

- A. General: Locate sign units and accessories where indicated, using mounting methods of the type described and in compliance with the manufacturer's instructions.
 - 1. Install signs level, plumb, and at the height indicated, with sign surfaces free from distortion or other defects in appearance.

- B. Dimensional Letters: Mount letters and numbers using standard pin fastening methods recommended by the manufacturer for letter form, type of mounting, substrate construction, and condition of exposure indicated. Provide heavy paper template to establish letter spacing and to locate holes for fasteners. Mount letters on aluminum pins that project 1/4" distance from the aluminum mounting tube. Anchor aluminum mounting tube back to steel studs. All fasteners shall be concealed in the finished work.
 - 1. Seal perimeter of stainless steel mounting tubes with sealant specified in Section 07 9200 - Joint Sealants.
 - 2. Projected Mounting: Mount characters at projection distance from wall surface indicated.
- C. Mounting heights above finish grade: Comply with ADA requirements.
 - 1. Handicapped parking sign: 4'-0" to top of sign.
 - 2. Ground-set installation: Install pipe post in 20" diameter by 2'-6" deep concrete footing. Set posts plumb and true in 3000 psi concrete; embed posts 2'-0", minimum. Crown concrete surface to shed water.
- D. Coat fabrications and anchors to be built into concrete construction using bituminous coating, 15 mils dry film thickness.

3.3 CLEANING AND PROTECTION:

- A. Protective Coverings:
 - 1. Restore protective coverings which have been damaged during shipment or installation of Work. Remove protection when requested for inspection of finishes and replace.
 - 2. Retain protective coverings intact and remove simultaneously from similarly finished items to preclude nonuniform oxidation and discoloration. Remove protective coverings only when there is no possibility of damage from other work yet to be performed at same location.
- B. After installation, clean soiled sign surfaces according to the manufacturer's instructions.
- C. Protect units from damage until acceptance by the Owner.

END OF SECTION

SECTION 10 2115 - PLASTIC TOILET COMPARTMENTS

PART 1 - GENERAL

1.1 SUMMARY:

- A. Related work specified elsewhere:
 - 1. Toilet accessories.
 - 2. Rough carpentry.
 - 3. Gypsum board.

1.2 ACTION SUBMITTALS:

- A. Shop drawings: Indicate plans and elevations of compartments, construction and fabrication details, anchoring and leveling details, plastic manufacturer, thickness, colors and patterns, hardware accessories and fastenings. Include manufacturer's installation and maintenance instructions.
- B. Samples:
 - 1. Plastic: Submit samples of manufacturer's standard colors and patterns for Architect's selection.
 - 2. Panel: Submit 1'-0" by 1'-0" sample of panel showing core construction with two sides and two edges, including one finished corner condition.
 - 3. Hardware: Submit actual sample of each hardware item.

1.3 QUALITY ASSURANCE:

- A. Applicable standards: Standards of American National Standards Institute (ANSI), A117.1.

1.4 PROJECT/SITE CONDITIONS:

- A. Coordinate gypsum board walls to receive toilet compartments so that blocking is attached between studs at points where toilet compartment mounting brackets will be located.
- B. Install toilet compartments after plumbing fixtures and floor, wall and ceiling finishes have been installed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS:

- A. Surface-burning characteristics: Comply with ASTM E 84 or UL 723; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame-Spread Index: 25 or less.
 - 2. Smoke-Developed Index: 450 or less.

2.2 SOLID PHENOLIC PLASTIC COMPARTMENTS:

- A. Acceptable manufacturers; subject to compliance with specified requirements:
 - 1. Basis of design; ASI, Accurate Partitions Corp.
 - 2. Global Partitions.
- B. Type:
 - 1. Ceiling hung, cross-braced compartments.
 - 2. Wall-hung urinal screens.
- C. Characteristics:
 - 1. Materials: Solid phenolic plastic core with high pressure melamine surfacing both faces, matte finish, colors as selected by Architect from manufacturer's standard, full color selection.

2. Colors: ASI, Accurate "Dove Gray #3010". Core colors shall match melamine surfacing, as approved by Architect.
 3. Edges: Exposed, beveled or rounded.
 4. Minimum thicknesses: 1"
 5. Fabrication: Cut and pre-drill panels in shop for hardware and toilet accessory items.
- D. Equip compartments with hardware including pilaster base, stainless steel shoes, polished chrome-plated, non-ferrous metal latch, bumper and keeper, combination bumper-coat hook. Stainless steel shall be AISI Type 302/304, polished finish. Provide wall bumper and door pull for outswinging doors.

2.3 HARDWARE AND FITTINGS:

- A. General: Provide heavy-duty, tamper-resistant hardware.
- B. Cross-braces: Extruded satin finish anodized aluminum, tubular section, anti-grip design, through-bolted to pilaster.
- C. Pilaster shoes: AISI Type 302/304 stainless steel, 3" high, hemmed top and bottom edges, die-formed to fit pilaster, polished finish.
- D. Hinges: Chrome-plated, non-ferrous metal or stainless steel, polished finish. Surface-mounted pivot design with stainless steel pivot pins and nylon, self-oiling graphite-bronze or thrust-frictionless bearings for moving parts. Hinges shall be mounted within door structure and adjustable so as to return door by gravity to a preset position when not latched.
- E. Wall and panel brackets: Provide individual wall brackets at panel-to-wall, pilaster-to-wall and panel-to-pilaster conditions, unless concealed type fasteners are used. Brackets shall be chrome-plated, non-ferrous metal, heavy duty type.
- F. Pilaster hanger: Manufacturer's standard galvanized anchorage device for attachment of pilaster to structural support and for leveling partition. Hanger consists of threaded rods, saddle, lock washers and leveling nuts.
- G. Latch, bumper and keeper: Chrome-plated, non-ferrous metal, polished finish, with resilient cushion stop.
- H. Door pull for out-swinging doors: Chrome-plated, non-ferrous metal or stainless steel, polished finish.
- I. Combination bumper/coat hook for in-swinging doors: Chrome-plated, non-ferrous metal, polished finish with rubber bumper.
- J. Coat hook for out-swinging doors: Chrome-plated, non-ferrous metal, polished finish. Mount to partition at height to meet handicapped accessibility requirements.
- K. Wall bumper for out-swinging doors: Polished, chrome-plated, non-ferrous metal, with rubber bumper; wall-mounted.
- L. Partition anchors:
 1. Non-corrosive, threaded sleeved anchors (sex-bolts) matching hardware finish, bolted through panels, tamper-resistant type.
 2. Provide stainless steel backing plate matching hardware finish where hardware is not of wraparound design.

PART 3 - EXECUTION

3.1 PREPARATION:

- A. Confirm dimensions, clearances, wall construction and plumbing fixture locations prior to partition installation.
- B. Install compartments after all finishes within area are complete and plumbing fixtures are installed.

3.2 INSTALLATION:

- A. Install compartments straight, plumb and anchored rigid to structure, complying with manufacturer's product data and approved shop drawings.
- B. Conceal evidence of cutting, drilling and fitting occurring on compartments, walls and floors.
- C. Clearances:
 - 1. Between panels and pilasters: 1/4" to 1/2".
 - 2. Between doors and pilasters: 1/8" nominal.
 - 3. Between panels and walls: 1/4" to 1/2".
- D. Anchorage:
 - 1. Secure pilasters to supporting structural framing with manufacturer's standard pilaster hangers. Pilaster hangers shall not transmit load to finished ceilings. Tighten pilaster hanger fasteners. Secure pilaster shoes in position against finished ceiling.
 - 2. Secure cross-braces to walls using brackets attached with at least two sleeved anchors. Through-bolt brace to pilasters using two bolts per stile.
 - 3. At panel-to-wall, pilaster to wall and panel-to-pilaster conditions, attach panels and pilasters using a minimum of three brackets each, anchored using through-bolts and sleeved anchors. Space individual brackets near top, bottom and center of panels.
 - 4. Locate brackets so that holes for wall anchors occur in masonry or tile joints where possible.
 - 5. Attach urinal screens using not less than three brackets, spaced not over 1'-4" o. c.

3.3 ADJUSTMENT AND CLEANING:

- A. Adjust doors to align with pilasters and overhead brace, operate freely without excessive force and stop 15 degrees from closed position when unlatched. Out-swinging handicapped partition doors shall return to closed position.
- B. Clean compartments and hardware using methods approved by panel manufacturer.
- C. Coordinate installation of accessories specified in another section.
- D. Tighten anchors to ensure rigid installation.

END OF SECTION

SECTION 10 2600 - CORNER PROTECTION

PART 1 - GENERAL

1.1 SUMMARY:

- A. Work of this section includes corner guards at indicated locations.
- B. Related work specified elsewhere: Gypsum board.

1.2 ACTION SUBMITTALS:

- A. Submit product data and detailed specifications for each system component and installation accessory required, including installation methods for each type of substrate.
- B. Submit shop drawings showing locations, extent and installation details of corner protection. Show methods of attachment to adjoining construction.
- C. Samples for verification purposes: Submit five (5) 12" long sample of each model specified and as proposed for this work, for verification of guard.

1.3 DELIVERY, STORAGE AND HANDLING:

- A. Deliver materials to the project site in unopened original factory packaging clearly labeled to show manufacturer.
- B. Store materials in original, undamaged packaging in a cool, dry place out of direct sunlight and exposure to the elements. Maintain a minimum room temperature of 40°F and a maximum of temperature of 100°F.
- C. Store material flat.

PART 2 - PRODUCTS

2.1 CORNER GUARDS; CG-1:

- A. Acceptable manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. CG-1 Basis of design; Construction Specialties, Inc., Acrovyn CO-8 Stainless Steel, #407 Silver, surface mount, Corner Guard Assembly.
 - 2. Arden Architectural Specialties, Inc.
 - 3. IPC Door and Wall Protection Systems; Division of InPro Corporation.
- B. Characteristics:
 - 1. Material: Stainless steel, Type 304.
 - a. Thickness: Minimum 0.0625".
 - b. Finish: Directional satin, No. 4.
 - 2. Wing size: Nominal 3" by 3".
 - 3. Corner radius: 1/8".
 - 4. Mounting: Surface mount.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. Install corner protections at locations indicated on drawings. Attach in accord with manufacturer's product data, using manufacturer's standard wall mounting brackets and fasteners spaced in accord with manufacturer's product data.
- B. Temperature at the time of installation must be between 65°-75°F and be maintained for at least 48 hours after the installation.
- C. Protect prefinished surfaces from damage or staining. Clean surfaces prior to Date of Substantial Completion.
- D. Unless indicated otherwise, install corner guards above base to 4'-0" high.

END OF SECTION

SECTION 10 2813 - TOILET ACCESSORIES

PART 1 - GENERAL

1.1 ACTION SUBMITTALS:

- A. Product Data:
 - 1. Complete schedule and brochures containing catalog cuts and technical data for each individual item.
 - 2. Mark out all nonapplicable data.
- B. Samples:
 - 1. Furnish samples of each item, when requested by Architect.
 - 2. Approved samples will be returned and may be incorporated into Project.
 - 3. Identify installed samples.

1.2 INFORMATIONAL SUBMITTALS:

- A. Product Schedule:
 - 1. Identify locations using room designations indicated on Drawings.
 - 2. Identify products using designations indicated on Drawings.

1.3 DELIVERY, STORAGE, AND HANDLING:

- A. Do not deliver accessories to Project site until rooms are ready to receive them.
- B. Pack accessories individually in manner to protect accessory and its finish.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

- A. Acceptable Manufacturers: All accessories product of single manufacturer. Subject to compliance with all requirements of this specification, provide named products and systems or comparable products and systems by one of following manufacturers:
 - 1. American Specialties, Inc.
 - 2. Basis of design: Bobrick Washroom Equipment, Inc. items are listed herein to establish quality and design standards for toilet accessories.
 - 3. Bradley Washfountain Co.
 - 4. McKinney/Parker.

2.2 WASHROOM ACCESSORIES:

- A. Finish: No. 4 satin stainless steel, unless indicated otherwise.
- B. Toilet accessories:
 - 1. Item 01; Diaper Changing Station: Bobrick KB110-SSRE.
 - a. Mount per ADA requirements so that accessory is not a protruding object.
 - b. Engineered to support a minimum of 250 lb static weight when opened.
 - 2. Item 02; Recessed Sanitary Napkin/Tampon Vendor B-4706 25 cent.
 - 3. Item 03; Combination Towel (Folded) Dispenser/Waste Receptacle: Bobrick B-35643.
 - 4. Item 08; Fixed Framed Mirrors: Bobrick B-290-2448, 1/4" thick No. 1 quality float glass electrolytically copper backed in 3/4" by 3/4" stainless steel frame. Number and locations indicated on drawings.

5. Item 11; Sanitary-Napkin Disposal Unit: Bobrick B-270 (wall) and Bobrick B-4354 (toilet partition).
 6. Items 12 and 13; Grab Bars: Item 13; Bobrick B-6806 x 36" and Item 12; Bobrick B-6806 x 42".
 7. Item 14; Mop and Broom Holder: Bobrick B-224 x 36
 8. Item 15; Coat Hook: Bobrick B-818.
- C. Owner furnished toilet accessories:
1. Item 04; Surface Mounted Paper Towel Dispenser (by Owner)
 2. Item 06; Surface Mounted Soap Dispenser (by Owner).
 3. Item 07; Lavatory Mounted Soap Dispenser (by Owner).
 4. Item 10; Surface Mounted Toilet Tissue: By Owner.
- D. Underlavatory Guards:
1. Acceptable manufacturers:
 - a. Plumberex Specialty Products, Inc.
 - b. TCI Products.
 - c. Truebro, Inc.
 2. Description: Insulating pipe covering for supply and drain piping assemblies, that prevent direct contact with and burns from piping, and allow service access without removing coverings.
 3. Material and Finish: Antimicrobial, molded-plastic, white.

2.3 FABRICATION:

- A. Cabinet Construction: Constructed of ASTM A666, Type 302/304 stainless steel, minimum 22 gauge, except doors of flush face cabinets minimum 18 gauge, #4 satin finish.
1. Unit Construction: Seamless or welded, all welds ground smooth prior to finishing on exposed surfaces. Full, continuous backs and sides. Flush face units seamless construction.
 2. Hinges: Continuous stainless steel piano hinges.
 3. Stops: Spring or cable stops located inside cabinet to limit opening to 120 degrees maximum.
 4. Bumpers: Rubber bumpers to cushion door closing.
 5. Exposed Edges: Hemmed return, or flanged; sharp edges not allowable.
 6. Waste Receptacle Liners: Rigid, leakproof molded plastic.
 7. Paper Towel Dispensers: Adaptable to dispense C-fold, multi-fold or single-fold towels without use of additional towel trays.
 8. Feminine Napkin/Tampon Vendors: Changeable coin mechanisms and coin slot identification; lockable coin box keyed differently from other accessories.
 9. Combination Towel/Waste Units: Capable of mounting such that towel dispenser is located 3'-4" above finish floor while allowing minimum 4-inch base below unit.
- B. Provide steel anchor plates and anchor components for installation on building finishes.
- C. Form surfaces flat without distortion. Maintain flat surfaces without scratches or dents.
- D. Back paint components with bituminous paint where contact is made with building finishes to prevent electrolysis.
- E. Hot-dip galvanize ferrous metal anchors and fastening devices.
- F. Shop assemble components and package complete with anchors and fittings.

PART 3 - EXECUTION

3.1 PREPARATION:

- A. Size rough openings for recessed accessories. Coordinate accessory installation with gypsum board and ceramic tile work. Provide wood blocking and grounds necessary for proper anchorage.
- B. Furnish concealed anchor plates to be built into stud walls.
- C. Furnish proper location and size of opening required for partition mounted items to toilet compartment manufacturer.
- D. Furnish locations for grab bar concealed anchor plates to be built into walls.

3.2 INSTALLATION:

- A. Install accessories in compliance with manufacturer's recommendations, unless indicated otherwise.
- B. Install accessories true, plumb and level, to fit snug and tight against wall surface.
 - 1. Use concealed fasteners wherever possible.
 - 2. Use tamper-proof bolts and screws for exposed fasteners.
- C. Mounting Heights: Except as otherwise indicated, heights are given above finish floor (AFF) to top of accessory.
 - 1. Grab Bars: 2'-10" AFF to centerline. Installed grab bar and anchors must withstand more than 250 pounds of force.
- D. Provide key locked accessories keyed alike.

END OF SECTION

SECTION 104413 - FIRE PROTECTION CABINETS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

- 1. Fire-protection cabinets for the following:
 - a. Portable fire extinguisher.

- B. Related Requirements:

- 1. Section 104416 "Fire Extinguishers" for portable, hand-carried fire extinguishers accommodated by fire-protection cabinets
- 2. Section 211200 "Fire-Suppression Standpipes" for fire-hose connections. Retain products and Work included in this Section that are covered by cash or quantity allowance. Do not include amounts. Insert descriptions of items in Part 2 or 3 to provide information affecting the cost of the Work that is not included under the allowance.

- C. PREINSTALLATION CONFERENCE

- D. Preinstallation Conference: Conduct conference at **Project site**.

- 1. Review methods and procedures related to fire-protection cabinets, including, but not limited to, the following:
 - a. Schedules and coordination requirements.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

- 1. Show door hardware, cabinet type, trim style, and panel style. Include roughing-in dimensions and details showing recessed, semirecessed, or surface-mounting method and relationships of box and trim to surrounding construction.
- 2. Show location of knockouts for hose valves.

- B. Shop Drawings: For fire-protection cabinets.
 - 1. Include plans, elevations, sections, details, and attachments to other work.
- C. Samples: For each type of exposed finish required.
- D. Samples for Initial Selection: For each type of exposed finish required.
- E. Samples for Verification: For each type of exposed finish required, prepared on samples 6 by 6 inches (150 by 150 mm) square.
- F. Product Schedule: For fire-protection cabinets. Indicate whether recessed, semirecessed, or surface mounted. Coordinate final fire-protection cabinet schedule with fire-extinguisher schedule to ensure proper fit and function. **Use same designations indicated on Drawings.**

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For fire-protection cabinets to include in maintenance manuals.

1.5 COORDINATION

- A. Coordinate size of fire-protection cabinets to ensure that type and capacity of **fire extinguishers** indicated are accommodated.
- B. Coordinate sizes and locations of fire-protection cabinets with wall depths.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Source Limitations: Obtain fire-protection cabinets, accessories, and fire extinguishers from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. Fire-Rated Fire-Protection Cabinets: Listed and labeled to comply with requirements in ASTM E814 for fire-resistance rating of walls where they are installed.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 FIRE-PROTECTION CABINET – See drawings.

- A. Cabinet Type: Suitable for fire **extinguisher**.
- B. Cabinet Construction: **One-hour fire rated**.
 - 1. Fire-Rated Cabinets: Construct fire-rated cabinets with double walls fabricated from 0.043-inch- (1.09-mm-) thick cold-rolled steel sheet lined with minimum 5/8-inch- (16-mm-) thick fire-barrier material. Provide factory-drilled mounting holes.
- C. Cabinet Material: **Cold-rolled steel sheet**.
 - 1. Shelf: Same metal and finish as cabinet.
- D. Recessed Cabinet:
 - 1. Trimless with Concealed Flange: Surface of surrounding wall finishes flush with exterior finished surface of cabinet frame and door, without overlapping trim attached to cabinet. Provide recessed flange, of same material as box, attached to box, to act as **drywall bead**.
 - 2. Trimless with Hidden Flange: Flange of same metal and finish as box overlaps surrounding wall finish and is concealed from view by an overlapping door.
 - 3. Exposed Flat Trim: One-piece combination trim and perimeter door frame overlapping surrounding wall surface, with exposed trim face and wall return at outer edge (backbend).
- E. Semirecessed Cabinet: One-piece combination trim and perimeter door frame overlapping surrounding wall surface, with exposed trim face and wall return at outer edge (backbend).
 - 1. Square-Edge Trim: 1-1/4- to 1-1/2-inch (32- to 38-mm) backbend depth.
 - 2. Rolled-Edge Trim: **4-inch (102-mm)** backbend depth.
- F. Surface-Mounted Cabinet: Cabinet box fully exposed and mounted directly on wall with no trim.
- G. Cabinet Trim Material: **Steel sheet**.
- H. Door Material: **Steel sheet**.
- I. Door Style: **Fully glazed panel with frame**.
- J. Door Glazing: **Tempered float glass (clear)**.
 - 1. Acrylic Sheet Color: **Clear** transparent acrylic sheet.
 - 2. Acrylic Sheet Color: Clear transparent acrylic sheet painted **red** on unexposed side.
 - 3. Acrylic Bubble Color: **Clear**, transparent.

- K. Door Hardware: Manufacturer's standard door-operating hardware of proper type for cabinet type, trim style, and door material and style indicated.
1. Provide **manufacturer's standard**.
manufacturer's standard hinge, permitting door to open 180 degrees.
- L. Accessories:
1. Mounting Bracket: Manufacturer's standard steel, designed to secure fire extinguisher to fire-protection cabinet, of sizes required for types and capacities of fire extinguishers indicated, with plated or baked-enamel finish.
 2. Break-Glass Strike: Manufacturer's standard metal strike, complete with chain and mounting clip, secured to cabinet.
 3. Break-Glass Door Handle: Manufacturer's standard, integral to glass with the words "PULL TO BREAK GLASS" applied to handle.
 4. Lettered Door Handle: One-piece, cast-iron door handle with the word "FIRE" embossed into face.
 5. Door Lock: **Cam lock that allows door to be opened during emergency by pulling sharply on door handle.**
 6. Identification: Lettering complying with authorities having jurisdiction for letter style, size, spacing, and location. Locate **as directed by Architect.**
 - a. Identify fire extinguisher in fire-protection cabinet with the words **FIRE EXTINGUISHER.**
 - 1) Location: Applied to **location indicated on Drawings.**
 - 2) Application Process: **Etched.**
 - 3) Lettering Color: **Black.**
 - 4) Orientation: **Vertical.**
 7. Alarm: Manufacturer's standard alarm that actuates when fire-protection cabinet door is opened and that is powered by **batteries.**
- M. Materials:
1. Cold-Rolled Steel: ASTM A1008/A1008M, Commercial Steel (CS), Type B.
 - a. Finish: **Baked enamel, TGIC polyester powder coat.**
 - b. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - c. Color: **As selected by Architect from manufacturer's full range.**
 2. Aluminum: ASTM B221 (ASTM B221M) for extruded shapes and aluminum sheet, with strength and durability characteristics of not less than Alloy 6063-T5 for aluminum sheet.
 - a. Finish: **Baked enamel or powder coat.**
 - b. Color: **As selected by Architect from full range of industry colors and color densities.**

3. Stainless Steel: ASTM A240/A240M or ASTM A666, Type 304.
 - a. Finish: **ASTM A480/A480M No. 4 directional satin finish**

2.4 FABRICATION

- A. Fire-Protection Cabinets: Provide manufacturer's standard box (tub) with trim, frame, door, and hardware to suit cabinet type, trim style, and door style indicated.
 1. Weld joints and grind smooth.
 2. Miter corners and grind smooth.
 3. Provide factory-drilled mounting holes.
 4. Prepare doors and frames to receive locks.
 5. Install door locks at factory.
- B. Cabinet Doors: Fabricate doors according to manufacturer's standards, from materials indicated and coordinated with cabinet types and trim styles.
 1. Fabricate door frames with tubular stiles and rails and hollow-metal design, minimum 1/2 inch (13 mm) thick.
 2. Fabricate door frames of one-piece construction with edges flanged.
 3. Miter and weld perimeter door frames and grind smooth.
- C. Cabinet Trim: Fabricate cabinet trim in one piece with corners mitered, welded, and ground smooth.

2.5 GENERAL FINISH REQUIREMENTS

- A. Comply with NAAMM's AMP 500, "Metal Finishes Manual for Architectural and Metal Products," for recommendations for applying and designating finishes.
- B. Protect mechanical finishes on exposed surfaces of fire-protection cabinets from damage by applying a strippable, temporary protective covering before shipping.
- C. Finish fire-protection cabinets after assembly.
- D. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for hose [**valves**] [**racks**] and cabinets to verify actual locations of piping connections before cabinet installation.

- B. Examine walls and partitions for suitable framing depth and blocking where [**recessed**] [**and**] [**semirecessed**] cabinets will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Prepare recesses for **recess and semirecessed** fire-protection cabinets as required by type and size of cabinet and trim style.

3.3 INSTALLATION

- A. General: Install fire-protection cabinets in locations and at mounting heights indicated
- B. Retain "Fire-Protection Cabinets" Subparagraph below if retaining first option in "General" Paragraph above. If more than one height is required, indicate locations for each height. According to NFPA 10, maximum mounting height for fire extinguishers weighing 40 lb (18 kg) or less is 60 inches (1524 mm) from finished floor to top of extinguisher; for those weighing more, it is 42 inches (1067 mm) from finished floor to top of extinguisher. In rooms required to comply with ADA-ABA Guidelines, mounting height for fire extinguishers is not to exceed 48 inches (1219 mm) to the handle.
 - 1. Fire-Protection Cabinets: [**42 inches (1067 mm)**] above finished floor to top of fire extinguisher.
- C. Fire-Protection Cabinets: Fasten cabinets to structure, square and plumb.
 - 1. Unless otherwise indicated, provide recessed fire-protection cabinets. If wall thickness is inadequate for recessed cabinets, provide semirecessed fire-protection cabinets.
 - 2. Provide inside latch and lock for break-glass panels.
 - 3. Fasten mounting brackets to inside surface of fire-protection cabinets, square and plumb.
 - 4. Fire-Rated [**Hose and Valve**] [**Hose-Valve**] Cabinets:
 - a. Install cabinet with not more than 1/16-inch (1.6-mm) tolerance between pipe OD and knockout OD. Center pipe within knockout.
 - b. Seal through penetrations with firestopping sealant as specified in Section 078413 "Penetration Firestopping."
- D. Identification:
 - 1. Apply **vinyl lettering** at locations indicated.
 - 2. Apply **vinyl lettering** on field-painted fire-protection cabinets after painting is complete.

3.4 ADJUSTING AND CLEANING

- A. Remove temporary protective coverings and strippable films, if any, as fire-protection cabinets are installed unless otherwise indicated in manufacturer's written installation instructions.
- B. Adjust fire-protection cabinet doors to operate easily without binding. Verify that integral locking devices operate properly.
- C. On completion of fire-protection cabinet installation, clean interior and exterior surfaces as recommended by manufacturer.
- D. Touch up marred finishes, or replace fire-protection cabinets that cannot be restored to factory-finished appearance. Use only materials and procedures recommended or furnished by fire-protection cabinet and mounting bracket manufacturers.
- E. Replace fire-protection cabinets that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION 104413

Special Specification RMA2

Section 032000

Rebar/WWF

SECTION 032000 - CONCRETE REINFORCING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel reinforcement bars.
2. Welded-wire reinforcement.

B. Related Requirements:

1. Section 321313 "Concrete Paving" for reinforcing related to concrete pavement and walks.
2. Section 321316 "Decorative Concrete Paving" for reinforcing related to decorative concrete pavement and walks.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Review the following:
 - a. Special inspection and testing and inspecting agency procedures for field quality control.
 - b. Construction contraction and isolation joints.
 - c. Steel-reinforcement installation.

1.3 ACTION SUBMITTALS

A. Product Data: For the following:

1. Each type of steel reinforcement.
2. Bar supports.
3. Mechanical splice couplers.

B. Shop Drawings: Comply with ACI SP-066:

1. Include placing drawings that detail fabrication, bending, and placement.
2. Include bar sizes, lengths, materials, grades, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, location of splices, lengths of lap splices, details of mechanical splice couplers, details of welding splices, tie spacing, hoop spacing, and supports for concrete reinforcement.

C. Construction Joint Layout: Indicate proposed construction joints required to build the structure.

1. Location of construction joints is subject to approval of the Architect.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Statements: For testing and inspection agency.

1. Experience providing delegated-design engineering services of the type indicated.
2. Documentation that delegated-design engineer is licensed in the jurisdiction in which Project is located.

B. Welding certificates.

1. Reinforcement To Be Welded: Welding procedure specification in accordance with AWS D1.4/D1.4M

C. Material Test Reports: For the following, from a qualified testing agency:

1. Steel Reinforcement:
 - a. For reinforcement to be welded, mill test analysis for chemical composition and carbon equivalent of the steel in accordance with ASTM A706/A706M.
2. Mechanical splice couplers.

D. Field quality-control reports.

E. Minutes of preinstallation conference.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, acceptable to authorities having jurisdiction, qualified in accordance with ASTM C1077 and ASTM E329 for testing indicated.

B. Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.4/D 1.4M.

C. Mockups: Reinforcing for cast-concrete formed surfaces, to demonstrate tolerances and standard of workmanship.

1. Build panel approximately 100 sq. ft. for formed surface in the location indicated on Drawings or, if not indicated, as directed by Architect.
2. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage.
 - 1. Store reinforcement to avoid contact with earth.

PART 2 - PRODUCTS

2.1 STEEL REINFORCEMENT

- A. Reinforcing Bars: ASTM A615/A615M, Grade 60, deformed.
- B. Low-Alloy Steel Reinforcing Bars: ASTM A706/A706M, deformed.
- C. Headed-Steel Reinforcing Bars: ASTM A970/A970M.
- D. Steel Bar Mats: ASTM A184/A184M, fabricated from ASTM A615/A615M, Grade 60, deformed bars, assembled with clips.
- E. Plain-Steel Welded-Wire Reinforcement: ASTM A1064/A1064M, plain, fabricated from as-drawn steel wire into flat sheets.
- F. Deformed-Steel Welded-Wire Reinforcement: ASTM A1064/A1064M, flat sheet.

2.2 REINFORCEMENT ACCESSORIES

- A. Joint Dowel Bars: ASTM A615/A615M, Grade 60, plain-steel bars, cut true to length with ends square and free of burrs.
- B. Epoxy-Coated Joint Dowel Bars: ASTM A615/A615M, Grade 60, plain-steel bars, ASTM A775/A775M epoxy coated.
- C. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded-wire reinforcement in place.
 - 1. Manufacture bar supports from steel wire, plastic, or precast concrete in accordance with CRSI's "Manual of Standard Practice," of greater compressive strength than concrete and as follows:
 - a. For concrete surfaces exposed to view, where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected steel wire, all-plastic bar supports, or CRSI Class 2 stainless steel bar supports.
 - b. For epoxy-coated reinforcement, use CRSI Class 1A epoxy-coated or other dielectric-polymer-coated wire bar supports.
 - c. For dual-coated reinforcement, use CRSI Class 1A epoxy-coated or other dielectric-polymer-coated wire bar supports.

- d. For zinc-coated reinforcement, use galvanized wire or dielectric-polymer-coated wire bar supports.
 - e. For stainless steel reinforcement, use CRSI Class 1 plastic-protected steel wire, all-plastic bar supports, or CRSI Class 2 stainless steel bar supports.
- D. Mechanical Splice Couplers: ACI 318 Type 1, same material of reinforcing bar being spliced; tension-compression type.
- E. Steel Tie Wire: ASTM A1064/A1064M, annealed steel, not less than 0.0508 inch in diameter.
 - 1. Finish: Plain.

2.3 FABRICATING REINFORCEMENT

- A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protection of In-Place Conditions:
 - 1. Do not cut or puncture vapor retarder.
 - 2. Repair damage and reseal vapor retarder before placing concrete.
- B. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials that reduce bond to concrete.

3.2 INSTALLATION OF STEEL REINFORCEMENT

- A. Comply with CRSI's "Manual of Standard Practice" for placing and supporting reinforcement.
- B. Accurately position, support, and secure reinforcement against displacement.
 - 1. Locate and support reinforcement with bar supports to maintain minimum concrete cover.
 - 2. Do not tack weld crossing reinforcing bars.
- C. Preserve clearance between bars of not less than 1 inch, not less than one bar diameter, or not less than 1-1/3 times size of large aggregate, whichever is greater.
- D. Provide concrete coverage in accordance with ACI 318.

- E. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.
- F. Splices: Lap splices as indicated on Drawings.
 - 1. Bars indicated to be continuous, and all vertical bars shall be lapped not less than 36 bar diameters at splices, or 24 inches, whichever is greater.
 - 2. Stagger splices in accordance with ACI 318.
 - 3. Mechanical Splice Couplers: Install in accordance with manufacturer's instructions.
 - 4. Weld reinforcing bars in accordance with AWS D1.4/D 1.4M, where indicated on Drawings.
- G. Install welded-wire reinforcement in longest practicable lengths.
 - 1. Support welded-wire reinforcement in accordance with CRSI "Manual of Standard Practice."
 - a. For reinforcement less than W4.0 or D4.0, continuous support spacing shall not exceed 12 inches.
 - 2. Lap edges and ends of adjoining sheets at least one wire spacing plus 2 inches for plain wire and 8 inches for deformed wire.
 - 3. Offset laps of adjoining sheet widths to prevent continuous laps in either direction.
 - 4. Lace overlaps with wire.

3.3 JOINTS

- A. Construction Joints: Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect.
 - 1. Place joints perpendicular to main reinforcement.
 - 2. Continue reinforcement across construction joints unless otherwise indicated.
 - 3. Do not continue reinforcement through sides of strip placements of floors and slabs.
- B. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt coat one-half of dowel length, to prevent concrete bonding to one side of joint.

3.4 INSTALLATION TOLERANCES

- A. Comply with ACI 117.

3.5 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a special inspector and qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

- B. Testing Agency: Engage a qualified testing and inspecting agency to perform tests and inspections and to submit reports.
- C. Inspections:
 - 1. Steel-reinforcement placement.
 - 2. Steel-reinforcement mechanical splice couplers.
 - 3. Steel-reinforcement welding.
- D. Manufacturer's Inspections: Engage manufacturer of structural thermal break insulated connection system to inspect completed installations prior to placement of concrete, and to provide written report that installation complies with manufacturer's written instructions.

END OF SECTION

Special Specification RMA3

Section 033000

Slab-On-Ground/Strip Footing/Spread Footing/Slab-On-Deck

SECTION 033000 - CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cast-in-place concrete, including concrete materials, mixture design, placement procedures, and finishes.

B. Related Requirements:

1. Section 031000 "Concrete Forming and Accessories" for form-facing materials, form liners, insulating concrete forms, and waterstops.
2. Section 032000 "Concrete Reinforcing" for steel reinforcing bars and welded-wire reinforcement.

1.2 DEFINITIONS

- A. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash, slag cement, other pozzolans, and silica fume; materials subject to compliance with requirements.

- B. Water/Cement Ratio (w/cm): The ratio by weight of water to cementitious materials.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1. Require representatives of each entity directly concerned with cast-in-place concrete to attend, including the following:
 - a. Contractor's superintendent.
 - b. Independent testing agency responsible for concrete design mixtures.
 - c. Ready-mix concrete manufacturer.
 - d. Concrete Subcontractor.
 - e. Special concrete finish Subcontractor.
2. Review the following:
 - a. Special inspection and testing and inspecting agency procedures for field quality control.
 - b. Construction joints, control joints, isolation joints, and joint-filler strips.
 - c. Semirigid joint fillers.
 - d. Vapor-retarder installation.
 - e. Anchor rod and anchorage device installation tolerances.
 - f. Cold and hot weather concreting procedures.

- g. Concrete finishes and finishing.
- h. Curing procedures.
- i. Forms and form-removal limitations.
- j. Shoring and reshoring procedures.
- k. Methods for achieving specified floor and slab flatness and levelness.
- l. Floor and slab flatness and levelness measurements.
- m. Concrete repair procedures.
- n. Concrete protection.
- o. Initial curing and field curing of field test cylinders (ASTM C31/C31M.)
- p. Protection of field cured field test cylinders.

1.4 ACTION SUBMITTALS

A. Product Data: For each of the following.

- 1. Portland cement.
- 2. Fly ash.
- 3. Slag cement.
- 4. Blended hydraulic cement.
- 5. Silica fume.
- 6. Performance-based hydraulic cement
- 7. Aggregates.
- 8. Admixtures:
 - a. Include limitations of use, including restrictions on cementitious materials, supplementary cementitious materials, air entrainment, aggregates, temperature at time of concrete placement, relative humidity at time of concrete placement, curing conditions, and use of other admixtures.
- 9. Vapor retarders.
- 10. Floor and slab treatments.
- 11. Liquid floor treatments.
- 12. Curing materials.
 - a. Include documentation from color pigment manufacturer, indicating that proposed methods of curing are recommended by color pigment manufacturer.
- 13. Joint fillers.
- 14. Repair materials.

B. Design Mixtures: For each concrete mixture, include the following:

- 1. Mixture identification.
- 2. Minimum 28-day compressive strength.
- 3. Durability exposure class.
- 4. Maximum w/cm.
- 5. Calculated equilibrium unit weight, for lightweight concrete.
- 6. Slump limit.
- 7. Air content.
- 8. Nominal maximum aggregate size.
- 9. Indicate amounts of mixing water to be withheld for later addition at Project site if permitted.

10. Include manufacturer's certification that permeability-reducing admixture is compatible with mix design.
11. Include certification that dosage rate for permeability-reducing admixture matches dosage rate used in performance compliance test.
12. Intended placement method.
13. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

C. Shop Drawings:

1. Construction Joint Layout: Indicate proposed construction joints required to construct the structure.
 - a. Location of construction joints is subject to approval of the Architect.

D. Concrete Schedule: For each location of each Class of concrete indicated in "Concrete Mixtures" Article, including the following:

1. Concrete Class designation.
2. Location within Project.
3. Exposure Class designation.
4. Formed Surface Finish designation and final finish.
5. Final finish for floors.
6. Curing process.
7. Floor treatment if any.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For the following:

1. Installer: Include copies of applicable ACI certificates.
2. Ready-mixed concrete manufacturer.
3. Testing agency: Include copies of applicable ACI certificates.

B. Material Certificates: For each of the following, signed by manufacturers:

1. Cementitious materials.
2. Admixtures.
3. Curing compounds.
4. Floor and slab treatments.
5. Bonding agents.
6. Adhesives.
7. Vapor retarders.
8. Semirigid joint filler.
9. Joint-filler strips.
10. Repair materials.

C. Material Test Reports: For the following, from a qualified testing agency:

1. Portland cement.
 2. Fly ash.
 3. Slag cement.
 4. Blended hydraulic cement.
 5. Silica fume.
 6. Performance-based hydraulic cement.
 7. Aggregates.
 8. Admixtures:
 - a. Permeability-Reducing Admixture: Include independent test reports, indicating compliance with specified requirements, including dosage rate used in test.
- D. Floor surface flatness and levelness measurements report, indicating compliance with specified tolerances.
- E. Research Reports:
1. For concrete admixtures in accordance with ICC's Acceptance Criteria AC198.
 2. For sheet vapor retarder/termite barrier, showing compliance with ICC AC380.
- F. Preconstruction Test Reports: For each mix design.
- G. Field quality-control reports.
- H. Minutes of preinstallation conference.
- 1.6 QUALITY ASSURANCE
- A. Installer Qualifications: A qualified installer who employs Project personnel qualified as an ACI-certified Flatwork Technician and Finisher and a supervisor who is a certified ACI Flatwork Concrete Finisher/Technician or an ACI Concrete Flatwork Technician.
1. Post-Installed Concrete Anchors Installers: ACI-certified Adhesive Anchor Installer.
- B. Ready-Mixed Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C94/C94M requirements for production facilities and equipment.
1. Manufacturer certified in accordance with NRMCA's "Certification of Ready Mixed Concrete Production Facilities."
- C. Laboratory Testing Agency Qualifications: A testing agency qualified in accordance with ASTM C1077 and ASTM E329 for testing indicated and employing an ACI-certified Concrete Quality Control Technical Manager.

1. Personnel performing laboratory tests shall be an ACI-certified Concrete Strength Testing Technician and Concrete Laboratory Testing Technician, Grade I. Testing agency laboratory supervisor shall be an ACI-certified Concrete Laboratory Testing Technician, Grade II.
- D. Field Quality Control Testing Agency Qualifications: An independent agency, acceptable to authorities having jurisdiction, qualified in accordance with ASTM C1077 and ASTM E329 for testing indicated.
 1. Personnel conducting field tests shall be qualified as an ACI Concrete Field Testing Technician, Grade 1, in accordance with ACI CPP 610.1 or an equivalent certification program.

1.7 PRECONSTRUCTION TESTING

- A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction testing on each concrete mixture.
 1. Include the following information in each test report:
 - a. Admixture dosage rates.
 - b. Slump.
 - c. Air content.
 - d. Seven-day compressive strength.
 - e. 28-day compressive strength.
 - f. Permeability.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Comply with ASTM C94/C94M and ACI 301.

1.9 FIELD CONDITIONS

- A. Cold-Weather Placement: Comply with ACI 301 and ACI 306.1 and as follows.
 1. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
 2. When average high and low temperature is expected to fall below 40 deg F for three successive days, maintain delivered concrete mixture temperature within the temperature range required by ACI 301.
 3. Do not use frozen materials or materials containing ice or snow.
 4. Do not place concrete in contact with surfaces less than 35 deg F, other than reinforcing steel.
 5. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.

- B. Hot-Weather Placement: Comply with ACI 301 and ACI 305.1, and as follows:
 - 1. Maintain concrete temperature at time of discharge to not exceed 95 deg F.
 - 2. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.

1.10 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to furnish replacement sheet vapor retarder/termite barrier material and accessories for sheet vapor retarder/ termite barrier and accessories that do not comply with requirements or that fail to resist penetration by termites within specified warranty period.
 - 1. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

- A. ACI Publications: Comply with ACI 301 unless modified by requirements in the Contract Documents.

2.2 CONCRETE MATERIALS

- A. Source Limitations:
 - 1. Obtain all concrete mixtures from a single ready-mixed concrete manufacturer for entire Project.
 - 2. Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant.
 - 3. Obtain aggregate from single source.
 - 4. Obtain each type of admixture from single source from single manufacturer.
- B. Cementitious Materials:
 - 1. Portland Cement: ASTM C150/C150M, Type I/II, gray.
 - 2. Fly Ash: ASTM C618, Class C or F.
 - 3. Slag Cement: ASTM C989/C989M, Grade 100 or 120.
 - 4. Silica Fume: ASTM C1240 amorphous silica.
- C. Normal-Weight Aggregates: ASTM C33/C33M, Class 3M coarse aggregate or better, graded. Provide aggregates from a single source.
 - 1. Alkali-Silica Reaction: Comply with one of the following:

- a. Expansion Result of Aggregate: Not more than 0.04 percent at one-year when tested in accordance with ASTM C1293.
 - b. Expansion Results of Aggregate and Cementitious Materials in Combination: Not more than 0.10 percent at an age of 16 days when tested in accordance with ASTM C1567.
 - c. Alkali Content in Concrete: Not more than 4 lb./cu. yd. for moderately reactive aggregate or 3 lb./cu. yd. for highly reactive aggregate, when tested in accordance with ASTM C1293 and categorized in accordance with ASTM C1778, based on alkali content being calculated in accordance with ACI 301.
 2. Maximum Coarse-Aggregate Size: 1 inch nominal.
 3. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
- D. Air-Entraining Admixture: ASTM C260/C260M.
- E. Chemical Admixtures: Certified by manufacturer to be compatible with other admixtures that do not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.
1. Water-Reducing Admixture: ASTM C494/C494M, Type A.
 2. Retarding Admixture: ASTM C494/C494M, Type B.
 3. Water-Reducing and -Retarding Admixture: ASTM C494/C494M, Type D.
 4. High-Range, Water-Reducing Admixture: ASTM C494/C494M, Type F.
 5. High-Range, Water-Reducing and -Retarding Admixture: ASTM C494/C494M, Type G.
 6. Plasticizing and Retarding Admixture: ASTM C1017/C1017M, Type II.
 7. Set-Accelerating Corrosion-Inhibiting Admixture: Commercially formulated, anodic inhibitor or mixed cathodic and anodic inhibitor; capable of forming a protective barrier and minimizing chloride reactions with steel reinforcement in concrete and complying with ASTM C494/C494M, Type C.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) BASF Corporation.
 - 2) Euclid Chemical Company (The); an RPM company.
 - 3) GCP Applied Technologies Inc.
 - 4) Sika Corporation.
 8. Non-Set-Accelerating Corrosion-Inhibiting Admixture: Commercially formulated, non-set-accelerating, anodic inhibitor or mixed cathodic and anodic inhibitor; capable of forming a protective barrier and minimizing chloride reactions with steel reinforcement in concrete.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) BASF Corporation.
 - 2) Cortec Corporation.
 - 3) GCP Applied Technologies Inc.
 - 4) Sika Corporation.

9. Permeability-Reducing Admixture: ASTM C494/C494M, Type S, hydrophilic, permeability-reducing crystalline admixture, capable of reducing water absorption of concrete exposed to hydrostatic pressure (PRAH).
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AQUAFIN, Inc.
 - 2) Kryton International Inc.
 - 3) Xypex Chemical Corporation.
 - b. Permeability: No leakage when tested in accordance with U.S. Army Corps of Engineers CRC C48 at a hydraulic pressure of 200 psi for 14 days.

- F. Water and Water Used to Make Ice: ASTM C94/C94M, potable

2.3 VAPOR RETARDERS

- A. Sheet Vapor Retarder, Class A: ASTM E1745, Class A; not less than 15 mils thick. Include manufacturer's recommended adhesive or pressure-sensitive tape.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Barrier-Bac; Intoplast Group.
 - b. Fortifiber Building Systems Group.
 - c. ISI Building Products.
 - d. Poly-America, L.P.
 - e. Raven Industries, Inc.
 - f. Reef Industries, Inc.
 - g. Stego Industries, LLC.
 - h. Tex-Trude.
 - i. W.R. Meadows, Inc.
- B. Sheet Vapor Retarder/Termite Barrier: ASTM E1745, Class A, except with maximum water-vapor permeance of 0.03 perms; complying with ICC AC380. Include manufacturer's recommended adhesive or pressure-sensitive tape.
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Polyguard Products, Inc.
 2. Low-Temperature Flexibility: Pass at minus 15 deg F; ASTM D146/D146M.
 3. Puncture Resistance: 224 lbf minimum; ASTM E154/E154M.
 4. Water Absorption: 0.1 percent weight-gain maximum after 48-hour immersion at 70 deg F; ASTM D570.
 5. Hydrostatic-Head Resistance: 231 feet minimum; ASTM D5385.

2.4 CURING MATERIALS

- A. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. BASF Corporation.
 - b. Bon Tool Co.
 - c. Brickform; a division of Solomon Colors.
 - d. ChemMasters, Inc.
 - e. Dayton Superior.
 - f. Euclid Chemical Company (The); an RPM company.
 - g. Kaufman Products, Inc.
 - h. Lambert Corporation.
 - i. Laticrete International, Inc.
 - j. Metalcrete Industries.
 - k. Nox-Crete Products Group.
 - l. Sika Corporation.
 - m. SpecChem, LLC.
 - n. TK Products.
 - o. Vexcon Chemicals Inc.
 - p. W.R. Meadows, Inc.
- B. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. when dry.
- C. Moisture-Retaining Cover: ASTM C171, polyethylene film burlap-polyethylene sheet.
 1. Color:
 - a. Ambient Temperature Below 50 deg F: Black.
 - b. Ambient Temperature between 50 deg F and 85 deg F: Any color.
 - c. Ambient Temperature Above 85 deg F: White.
- D. Curing Paper: Eight-feet- wide paper, consisting of two layers of fibered kraft paper laminated with double coating of asphalt.
 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Fortifiber Building Systems Group.
- E. Water: Potable or complying with ASTM C1602/C1602M.
- F. Clear, Waterborne, Membrane-Forming, Dissipating Curing Compound: ASTM C309, Type 1, Class B.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anti-Hydro International, Inc.
 - b. ChemMasters, Inc.
 - c. Dayton Superior.
 - d. Euclid Chemical Company (The); an RPM company.
 - e. Kaufman Products, Inc.
 - f. Lambert Corporation.

- g. Laticrete International, Inc.
 - h. Nox-Crete Products Group.
 - i. SpecChem, LLC.
 - j. TK Products.
 - k. Vexcon Chemicals Inc.
 - l. W.R. Meadows, Inc.
- G. Clear, Waterborne, Membrane-Forming, Nondissipating Curing Compound: ASTM C309, Type 1, Class B, certified by curing compound manufacturer to not interfere with bonding of floor covering.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anti-Hydro International, Inc.
 - b. BASF Corporation.
 - c. ChemMasters, Inc.
 - d. Dayton Superior.
 - e. Euclid Chemical Company (The); an RPM company.
 - f. Kaufman Products, Inc.
 - g. Lambert Corporation.
 - h. Laticrete International, Inc.
 - i. Metalcrete Industries.
 - j. Nox-Crete Products Group.
 - k. SpecChem, LLC.
 - l. TK Products.
 - m. Vexcon Chemicals Inc.
 - n. W.R. Meadows, Inc.
- H. Clear, Waterborne, Membrane-Forming, Curing Compound: ASTM C309, Type 1, Class B, 18 to 25 percent solids, nondissipating, certified by curing compound manufacturer to not interfere with bonding of floor covering.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. BASF Corporation.
 - b. ChemMasters, Inc.
 - c. Dayton Superior.
 - d. Euclid Chemical Company (The); an RPM company.
 - e. Kaufman Products, Inc.
 - f. Lambert Corporation.
 - g. Laticrete International, Inc.
 - h. Metalcrete Industries.
 - i. Nox-Crete Products Group.
 - j. SpecChem, LLC.
 - k. Vexcon Chemicals Inc.
 - l. V-Seal Concrete Sealers & Specialty Coatings.
 - m. W.R. Meadows, Inc.

- I. Clear, Solvent-Borne, Membrane-Forming, Curing and Sealing Compound: ASTM C1315, Type 1, Class A.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. BASF Corporation.
 - b. ChemMasters, Inc.
 - c. Concrete Sealers USA.
 - d. Dayton Superior.
 - e. Euclid Chemical Company (The); an RPM company.
 - f. Kaufman Products, Inc.
 - g. Lambert Corporation.
 - h. Laticrete International, Inc.
 - i. Metalcrete Industries.
 - j. Nox-Crete Products Group.
 - k. Right Pointe.
 - l. SpecChem, LLC.
 - m. TK Products.
 - n. Vexcon Chemicals Inc.
 - o. W.R. Meadows, Inc.
- J. Clear, Waterborne, Membrane-Forming, Curing and Sealing Compound: ASTM C1315, Type 1, Class A.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ChemMasters, Inc.
 - b. Concrete Sealers USA.
 - c. Dayton Superior.
 - d. Euclid Chemical Company (The); an RPM company.
 - e. Kaufman Products, Inc.
 - f. Lambert Corporation.
 - g. Laticrete International, Inc.
 - h. Metalcrete Industries.
 - i. Nox-Crete Products Group.
 - j. Right Pointe.
 - k. SpecChem, LLC.
 - l. TK Products.
 - m. Vexcon Chemicals Inc.
 - n. W.R. Meadows, Inc.

2.5 RELATED MATERIALS

- A. Expansion- and Isolation-Joint-Filler Strips: ASTM D1751, asphalt-saturated cellulosic fiber or ASTM D1752, cork or self-expanding cork.
- B. Semirigid Joint Filler: Two-component, semirigid, 100 percent solids, epoxy resin with a Type A shore durometer hardness of 80 in accordance with ASTM D2240.

- C. Bonding Agent: ASTM C1059/C1059M, Type II, nonredispersible, acrylic emulsion or styrene butadiene.
- D. Epoxy Bonding Adhesive: ASTM C881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade and class to suit requirements, and as follows:
 - 1. Types IV and V, load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.
- E. Floor Slab Protective Covering: Eight-feet- wide cellulose fabric.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. McTech Group, Inc.

2.6 REPAIR MATERIALS

- A. Repair Underlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/8 inch and that can be feathered at edges to match adjacent floor elevations.
 - 1. Cement Binder: ASTM C150/C150M portland cement or hydraulic or blended hydraulic cement, as defined in ASTM C219.
 - 2. Primer: Product of underlayment manufacturer recommended for substrate, conditions, and application.
 - 3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch or coarse sand, as recommended by underlayment manufacturer.
 - 4. Compressive Strength: Not less than 4100 psi at 28 days when tested in accordance with ASTM C109/C109M.
- B. Repair Overlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/4 inch and that can be filled in over a scarified surface to match adjacent floor elevations.
 - 1. Cement Binder: ASTM C150/C150M portland cement or hydraulic or blended hydraulic cement, as defined in ASTM C219.
 - 2. Primer: Product of topping manufacturer recommended for substrate, conditions, and application.
 - 3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch or coarse sand as recommended by topping manufacturer.
 - 4. Compressive Strength: Not less than 5000 psi at 28 days when tested in accordance with ASTM C109/C109M.

2.7 CONCRETE MIXTURES, GENERAL

- A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, in accordance with ACI 301.
 - 1. Use a qualified testing agency for preparing and reporting proposed mixture designs, based on laboratory trial mixtures.
- B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:
 - 1. Fly Ash or Other Pozzolans: 25 percent by mass.
 - 2. Slag Cement: 50 percent by mass.
 - 3. Silica Fume: 10 percent by mass.
 - 4. Total of Fly Ash or Other Pozzolans, Slag Cement, and Silica Fume: 50 percent by mass, with fly ash or pozzolans not exceeding 25 percent by mass and silica fume not exceeding 10 percent by mass.
 - 5. Total of Fly Ash or Other Pozzolans and Silica Fume: 35 percent by mass with fly ash or pozzolans not exceeding 25 percent by mass and silica fume not exceeding 10 percent by mass.
- C. Admixtures: Use admixtures in accordance with manufacturer's written instructions.
 - 1. Use water-reducing high-range water-reducing or plasticizing admixture in concrete, as required, for placement and workability.
 - 2. Use water-reducing and -retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
 - 3. Use water-reducing admixture in pumped concrete, concrete for heavy-use industrial slabs concrete for parking structure slabs, and concrete with a w/cm below 0.50.
 - 4. Use corrosion-inhibiting admixture in concrete mixtures where indicated.
 - 5. Use permeability-reducing admixture in concrete mixtures where indicated.

2.8 CONCRETE MIXTURES

- A. Class A: Normal-weight concrete used for footings, grade beams, and tie beams.
 - 1. Exposure Class: ACI 318 F0 S0 W0 C0.
 - 2. Minimum Compressive Strength: 4000 psi at 28 days.
 - 3. Maximum w/cm: 0.45.
 - 4. Slump Limit: 5 inches, plus or minus 1 inch 8 inches, plus or minus 1 inch for concrete with verified slump of 3 inches plus or minus 1 inch before adding high-range water-reducing admixture or plasticizing admixture at Project site.
 - 5. Slump Flow Limit: 22 inches, plus or minus 1.5 inches.
 - 6. Air Content:
 - a. Exposure Class F1: 4.5 percent, plus or minus 1.5 percent at point of delivery for concrete containing 1-inch nominal maximum aggregate size.

- b. Exposure Classes F2 and F3: 6 percent, plus or minus 1.5 percent at point of delivery for concrete containing 1-inch nominal maximum aggregate size.
 7. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.
- B. Class B: Normal-weight concrete used for foundation walls.
 1. Exposure Class: ACI 318 F0 S0 W0 C0.
 2. Minimum Compressive Strength: 4000 psi at 28 days.
 3. Maximum w/cm: 0.45.
 4. Slump Limit: 5 inches, plus or minus 1 inch 8 inches, plus or minus 1 inch for concrete with verified slump of 3 inches plus or minus 1 inch before adding high-range water-reducing admixture or plasticizing admixture at Project site.
 5. Slump Flow Limit: 22 inches, plus or minus 1.5 inches.
 6. Air Content:
 - a. Exposure Class F1: 4.5 percent, plus or minus 1.5 percent at point of delivery for concrete containing 1-inch nominal maximum aggregate size.
 - b. Exposure Classes F2 and F3: 6 percent, plus or minus 1.5 percent at point of delivery for concrete containing 1-inch nominal maximum aggregate size.
 7. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.
- C. Class C: Normal-weight concrete used for interior slabs-on-ground.
 1. Exposure Class: ACI 318 F0 S0 W0 C0.
 2. Minimum Compressive Strength: 4000 psi at 28 days.
 3. Maximum w/cm: 0.45.
 4. Minimum Cementitious Materials Content: 470 lb/cu. yd..
 5. Slump Limit: 5 inches, plus or minus 1 inch 8 inches, plus or minus 1 inch for concrete with verified slump of 3 inches plus or minus 1 inch before adding high-range water-reducing admixture or plasticizing admixture at Project site.
 6. Slump Flow Limit: 22 inches, plus or minus 1.5 inches.
 7. Air Content:
 - a. Do not use an air-entraining admixture or allow total air content to exceed 3 percent for concrete used in trowel-finished floors.
 8. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.
- D. Class I: Normal-weight concrete used for interior metal pan stairs and landings:
 1. Exposure Class: ACI 318 F0 S0 W0 C0.
 2. Minimum Compressive Strength: 3000 psi at 28 days.
 3. Maximum w/cm: 0.45.
 4. Minimum Cementitious Materials Content: 470 lb/cu. yd..
 5. Maximum Size Aggregate: 1/2 inch.
 6. Slump Limit: 3 inches, plus 1 inch or minus 2 inches.
 7. Air Content: 0 percent, plus or minus 0.5 percent at point of delivery.

8. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.
9. Retarding Admixture: Not allowed.
10. Accelerating Admixture: Not allowed.

E. Class J: Normal-weight concrete used for exterior retaining walls.

1. Exposure Class: ACI 318 F0 S0 W0 C0.
2. Minimum Compressive Strength: 4000 psi at 28 days.
3. Maximum w/cm: 0.45.
4. Slump Limit: 5 inches, plus or minus 1 inch 8 inches, plus or minus 1 inch for concrete with verified slump of 3 inches plus or minus 1 inch before adding high-range water-reducing admixture or plasticizing admixture at Project site.
5. Slump Flow Limit: 22 inches, plus or minus 1.5 inches.
6. Air Content:
 - a. Exposure Class F1: 4.5 percent, plus or minus 1.5 percent at point of delivery for concrete containing 1-inch nominal maximum aggregate size.
 - b. Exposure Classes F2 and F3: 6 percent, plus or minus 1.5 percent at point of delivery for concrete containing 1-inch nominal maximum aggregate size.
7. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.

2.9 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete in accordance with ASTM C94/C94M, and furnish batch ticket information.
- B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete in accordance with ASTM C94/C94M. Mix concrete materials in appropriate drum-type batch machine mixer.
 1. For mixer capacity of 1 cu. yd. or smaller, continue mixing at least 1-1/2 minutes, but not more than five minutes after ingredients are in mixer, before any part of batch is released.
 2. For mixer capacity larger than 1 cu. yd., increase mixing time by 15 seconds for each additional 1 cu. yd..
 3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixture time, quantity, and amount of water added. Record approximate location of final deposit in structure.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions:

1. Before placing concrete, verify that installation of concrete forms, accessories, and reinforcement, and embedded items is complete and that required inspections have been performed.
2. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Provide reasonable auxiliary services to accommodate field testing and inspections, acceptable to testing agency, including the following:

1. Daily access to the Work.
2. Incidental labor and facilities necessary to facilitate tests and inspections.
3. Secure space for storage, initial curing, and field curing of test samples, including source of water and continuous electrical power at Project site during site curing period for test samples.
4. Security and protection for test samples and for testing and inspection equipment at Project site.

3.3 INSTALLATION OF EMBEDDED ITEMS

A. Place and secure anchorage devices and other embedded items required for adjoining Work that is attached to or supported by cast-in-place concrete.

1. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of ANSI/AISC 303.
3. Install reglets to receive waterproofing and to receive through-wall flashings in outer face of concrete frame at exterior walls, where flashing is shown at lintels, shelf angles, and other conditions.

3.4 INSTALLATION OF VAPOR RETARDER

A. Sheet Vapor Retarders: Place, protect, and repair sheet vapor retarder in accordance with ASTM E1643 and manufacturer's written instructions.

1. Install vapor retarder with longest dimension parallel with direction of concrete pour.
2. Face laps away from exposed direction of concrete pour.
3. Lap vapor retarder over footings and grade beams not less than 6 inches, sealing vapor retarder to concrete.
4. Lap joints 6 inches and seal with manufacturer's recommended tape.

5. Terminate vapor retarder at the top of floor slabs, grade beams, and pile caps, sealing entire perimeter to floor slabs, grade beams, foundation walls, or pile caps.
 6. Seal penetrations in accordance with vapor retarder manufacturer's instructions.
 7. Protect vapor retarder during placement of reinforcement and concrete.
 - a. Repair damaged areas by patching with vapor retarder material, overlapping damages area by 6 inches on all sides, and sealing to vapor retarder.
- B. Bituminous Vapor Retarders: Place, protect, and repair bituminous vapor retarder in accordance with manufacturer's written instructions.

3.5 JOINTS

- A. Construct joints true to line, with faces perpendicular to surface plane of concrete.
- B. Construction Joints: Coordinate with floor slab pattern and concrete placement sequence.
1. Install so strength and appearance of concrete are not impaired, at locations indicated on Drawings or as approved by Architect.
 2. Place joints perpendicular to main reinforcement.
 - a. Continue reinforcement across construction joints unless otherwise indicated.
 - b. Do not continue reinforcement through sides of strip placements of floors and slabs.
 3. Form keyed joints as indicated. Embed keys at least 1-1/2 inches into concrete.
 4. Locate joints for beams, slabs, joists, and girders at third points of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
 5. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
 6. Space vertical joints in walls as indicated on Drawings. Unless otherwise indicated on Drawings, locate vertical joints beside piers integral with walls, near corners, and in concealed locations where possible.
 7. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
 8. Use epoxy-bonding adhesive at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
- C. Control Joints in Slabs-on-Ground: Form weakened-plane control joints, sectioning concrete into areas as indicated. Construct control joints for a depth equal to at least one-fourth of concrete thickness as follows:
1. Grooved Joints: Form control joints after initial floating by grooving and finishing each edge of joint to a radius of 1/8 inch. Repeat grooving of control joints after applying surface finishes. Eliminate groover tool marks on concrete surfaces.

2. Sawed Joints: Form control joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- wide joints into concrete when cutting action does not tear, abrade, or otherwise damage surface and before concrete develops random cracks.
- D. Isolation Joints in Slabs-on-Ground: After removing formwork, install joint-filler strips at slab junctions with vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.
1. Extend joint-filler strips full width and depth of joint, terminating flush with finished concrete surface unless otherwise indicated on Drawings.
 2. Terminate full-width joint-filler strips not less than 1/2 inch or more than 1 inch below finished concrete surface, where joint sealants, specified in Section 079200 "Joint Sealants," are indicated.
 3. Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together.
- E. Doweled Joints:
1. Install dowel bars and support assemblies at joints where indicated on Drawings.
 2. Lubricate or asphalt coat one-half of dowel bar length to prevent concrete bonding to one side of joint.
- F. Dowel Plates: Install dowel plates at joints where indicated on Drawings.

3.6 CONCRETE PLACEMENT

- A. Before placing concrete, verify that installation of formwork, reinforcement, embedded items, and vapor retarder is complete and that required inspections are completed.
1. Immediately prior to concrete placement, inspect vapor retarder for damage and deficient installation, and repair defective areas.
 2. Provide continuous inspection of vapor retarder during concrete placement and make necessary repairs to damaged areas as Work progresses.
- B. Notify Architect and testing and inspection agencies 24 hours prior to commencement of concrete placement.
- C. Do not add water to concrete during delivery, at Project site, or during placement unless approved by Architect in writing, but not to exceed the amount indicated on the concrete delivery ticket.
1. Do not add water to concrete after adding high-range water-reducing admixtures to mixture.

- D. Before test sampling and placing concrete, water may be added at Project site, subject to limitations of ACI 301, but not to exceed the amount indicated on the concrete delivery ticket.
 - 1. Do not add water to concrete after adding high-range water-reducing admixtures to mixture.
- E. Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete is placed on concrete that has hardened enough to cause seams or planes of weakness.
 - 1. If a section cannot be placed continuously, provide construction joints as indicated.
 - 2. Deposit concrete to avoid segregation.
 - 3. Deposit concrete in horizontal layers of depth not to exceed formwork design pressures and in a manner to avoid inclined construction joints.
 - 4. Consolidate placed concrete with mechanical vibrating equipment in accordance with ACI 301.
 - a. Do not use vibrators to transport concrete inside forms.
 - b. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches into preceding layer.
 - c. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity.
 - d. At each insertion, limit duration of vibration to time necessary to consolidate concrete, and complete embedment of reinforcement and other embedded items without causing mixture constituents to segregate.
- F. Deposit and consolidate concrete for floors and slabs in a continuous operation, within limits of construction joints, until placement of a panel or section is complete.
 - 1. Do not place concrete floors and slabs in a checkerboard sequence.
 - 2. Consolidate concrete during placement operations, so concrete is thoroughly worked around reinforcement and other embedded items and into corners.
 - 3. Maintain reinforcement in position on chairs during concrete placement.
 - 4. Screed slab surfaces with a straightedge and strike off to correct elevations.
 - 5. Level concrete, cut high areas, and fill low areas.
 - 6. Slope surfaces uniformly to drains where required.
 - 7. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, before excess bleedwater appears on the surface.
 - 8. Do not further disturb slab surfaces before starting finishing operations.

3.7 FINISHING FORMED SURFACES

- A. As-Cast Surface Finishes:
 - 1. ACI 301 Surface Finish SF-1.0: As-cast concrete texture imparted by form-facing material.
 - a. Patch voids larger than 1-1/2 inches wide or 1/2 inch deep.

- b. Remove projections larger than 1 inch.
 - c. Tie holes do not require patching.
 - d. Surface Tolerance: ACI 117 Class D.
 - e. Apply to concrete surfaces not exposed to public view.
 - 2. ACI 301 Surface Finish SF-2.0: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams.
 - a. Patch voids larger than 3/4 inch wide or 1/2 inch deep.
 - b. Remove projections larger than 1/4 inch.
 - c. Patch tie holes.
 - d. Surface Tolerance: ACI 117 Class B.
 - e. Locations: Apply to concrete surfaces exposed to public view, to receive a rubbed finish, or to be covered with a coating or covering material applied directly to concrete.
 - 3. ACI 301 Surface Finish SF-3.0:
 - a. Patch voids larger than 3/4 inch wide or 1/2 inch deep.
 - b. Remove projections larger than 1/8 inch.
 - c. Patch tie holes.
 - d. Surface Tolerance: ACI 117 Class A.
 - e. Locations: Apply to concrete surfaces exposed to public view, to receive a rubbed finish, or to be covered with a coating or covering material applied directly to concrete.
- B. Rubbed Finish: Apply the following to as cast surface finishes where indicated on Drawings:
 - 1. Smooth-Rubbed Finish:
 - a. Perform no later than one day after form removal.
 - b. Moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture.
 - c. If sufficient cement paste cannot be drawn from the concrete by the rubbing process, use a grout made from the same cementitious materials used in the in-place concrete.
 - d. Maintain required patterns or variances as shown on Drawings or to match design reference sample.
 - 2. Grout-Cleaned Rubbed Finish:
 - a. Clean concrete surfaces after contiguous surfaces are completed and accessible.
 - b. Do not clean concrete surfaces as Work progresses.
 - c. Mix 1 part portland cement to 1-1/2 parts fine sand, complying with ASTM C144 or ASTM C404, by volume, with sufficient water to produce a mixture with the consistency of thick paint. Add white portland cement in amounts determined by trial patches, so color of dry grout matches adjacent surfaces.
 - d. Wet concrete surfaces.
 - e. Scrub grout into voids and remove excess grout. When grout whitens, rub surface with clean burlap, and keep surface damp by fog spray for at least 36 hours.
 - f. Maintain required patterns or variances as shown on Drawings or to match design reference sample.

3. Cork-Floated Finish:
 - a. Mix 1 part portland cement to 1 part fine sand, complying with ASTM C144 or ASTM C404, by volume, with sufficient water to produce a mixture with the consistency of thick paint.
 - b. Mix 1 part portland cement and 1 part fine sand with sufficient water to produce a mixture of stiff grout. Add white portland cement in amounts determined by trial patches, so color of dry grout matches adjacent surfaces.
 - c. Wet concrete surfaces.
 - d. Compress grout into voids by grinding surface.
 - e. In a swirling motion, finish surface with a cork float.
 - f. Maintain required patterns or variances as shown on Drawings or to match design reference sample.
4. Scrubbed Finish: After concrete has achieved a compressive strength of from 1000 to 1500 psi, apply scrubbed finish.
 - a. Wet concrete surfaces thoroughly and scrub with stiff fiber or wire brushes, using water freely, until top mortar surface is removed and aggregate is uniformly exposed.
 - b. Rinse scrubbed surfaces with clean water.
 - c. Maintain continuity of finish on each surface or area of Work.
 - d. Remove only enough concrete mortar from surfaces to match design reference sample.

C. Related Unformed Surfaces:

1. At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a color and texture matching adjacent formed surfaces.
2. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces unless otherwise indicated.

3.8 FINISHING FLOORS AND SLABS

- A. Comply with ACI 302.1R recommendations for screeding, restraightening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.
- B. Scratch Finish:
 1. While still plastic, texture concrete surface that has been screeded and bull-floated or darbied.
 2. Use stiff brushes, brooms, or rakes to produce a profile depth of 1/4 inch in one direction.
 3. Apply scratch finish to surfaces to receive concrete floor toppings to receive mortar setting beds for bonded cementitious floor finishes.
- C. Float Finish:

1. When bleedwater sheen has disappeared and concrete surface has stiffened sufficiently to permit operation of specific float apparatus, consolidate concrete surface with power-driven floats or by hand floating if area is small or inaccessible to power-driven floats.
2. Repeat float passes and restraighening until surface is left with a uniform, smooth, granular texture and complies with ACI 117 tolerances for conventional concrete.
3. Apply float finish to surfaces to receive trowel finish and to be covered with fluid-applied or sheet waterproofing, built-up or membrane roofing, or sand-bed terrazzo.

D. Trowel Finish:

1. After applying float finish, apply first troweling and consolidate concrete by hand or power-driven trowel.
2. Continue troweling passes and restraighen until surface is free of trowel marks and uniform in texture and appearance.
3. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings.
4. Do not add water to concrete surface.
5. Do not apply hard-troweled finish to concrete, which has a total air content greater than 3 percent.
6. Apply a trowel finish to surfaces exposed to view or to be covered with resilient flooring, carpet, ceramic or quarry tile set over a cleavage membrane, paint, or another thin-film-finish coating system.
7. Finish surfaces to the following tolerances, in accordance with ASTM E1155, for a randomly trafficked floor surface:
 - a. Slabs on Ground:
 - 1) Specified overall values of flatness, F_F 25; and of levelness, F_L 20; with minimum local values of flatness, F_F 17; and of levelness, F_L 15.

E. Trowel and Fine-Broom Finish: Apply a first trowel finish to surfaces indicated on Drawings where ceramic or quarry tile is to be installed by either thickset or thinset method. While concrete is still plastic, slightly scarify surface with a fine broom perpendicular to main traffic route.

1. Coordinate required final finish with Architect before application.
2. Comply with flatness and levelness tolerances for trowel-finished floor surfaces.

F. Broom Finish: Apply a broom finish to exterior concrete platforms, steps, ramps, and locations indicated on Drawings.

1. Immediately after float finishing, slightly roughen trafficked surface by brooming with fiber-bristle broom perpendicular to main traffic route.
2. Coordinate required final finish with Architect before application.

3.9 INSTALLATION OF MISCELLANEOUS CONCRETE ITEMS

A. Filling In:

1. Fill in holes and openings left in concrete structures after Work of other trades is in place unless otherwise indicated.
2. Mix, place, and cure concrete, as specified, to blend with in-place construction.
3. Provide other miscellaneous concrete filling indicated or required to complete the Work.

B. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and by steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.

C. Equipment Bases and Foundations:

1. Coordinate sizes and locations of concrete bases with actual equipment provided.
2. Construct concrete bases 6 inches high unless otherwise indicated on Drawings, and extend base not less than 6 inches in each direction beyond the maximum dimensions of supported equipment unless otherwise indicated on Drawings, or unless required for seismic anchor support.
3. Minimum Compressive Strength: 4000 psi at 28 days.
4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete substrate.
6. Prior to pouring concrete, place and secure anchorage devices.
 - a. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - b. Cast anchor-bolt insert into bases.
 - c. Install anchor bolts to elevations required for proper attachment to supported equipment.

D. Steel Pan Stairs: Provide concrete fill for steel pan stair treads, landings, and associated items.

1. Cast-in inserts and accessories, as shown on Drawings.
2. Screed, tamp, and trowel finish concrete surfaces.

3.10 CONCRETE CURING

A. Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

1. Comply with ACI 301 and ACI 306.1 for cold weather protection during curing.
2. Comply with ACI 301 and ACI 305.1 for hot-weather protection during curing.

3. Maintain moisture loss no more than 0.2 lb/sq. ft. x h before and during finishing operations.

B. Curing Formed Surfaces: Comply with ACI 308.1 as follows:

1. Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces.
2. Cure concrete containing color pigments in accordance with color pigment manufacturer's instructions.
3. If forms remain during curing period, moist cure after loosening forms.
4. If removing forms before end of curing period, continue curing for remainder of curing period, as follows:
 - a. Continuous Fogging: Maintain standing water on concrete surface until final setting of concrete.
 - b. Continuous Sprinkling: Maintain concrete surface continuously wet.
 - c. Absorptive Cover: Pre-dampen absorptive material before application; apply additional water to absorptive material to maintain concrete surface continuously wet.
 - d. Water-Retention Sheeting Materials: Cover exposed concrete surfaces with sheeting material, taping, or lapping seams.
 - e. Membrane-Forming Curing Compound: Apply uniformly in continuous operation by power spray or roller in accordance with manufacturer's written instructions.
 - 1) Recoat areas subject to heavy rainfall within three hours after initial application.
 - 2) Maintain continuity of coating and repair damage during curing period.

C. Curing Unformed Surfaces: Comply with ACI 308.1 as follows:

1. Begin curing immediately after finishing concrete.
2. Interior Concrete Floors:
 - a. Floors to Receive Floor Coverings Specified in Other Sections: Contractor has option of the following:
 - 1) Absorptive Cover: As soon as concrete has sufficient set to permit application without marring concrete surface, install prewetted absorptive cover over entire area of floor.
 - a) Lap edges and ends of absorptive cover not less than 12-inches.
 - b) Maintain absorptive cover water saturated, and in place, for duration of curing period, but not less than seven days.
 - 2) Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive.
 - a) Immediately repair any holes or tears during curing period, using cover material and waterproof tape.
 - b) Cure for not less than seven days.

- 3) Ponding or Continuous Sprinkling of Water: Maintain concrete surfaces continuously wet for not less than seven days, utilizing one, or a combination of, the following:
 - a) Water.
 - b) Continuous water-fog spray.
- b. Floors to Receive Penetrating Liquid Floor Treatments: Contractor has option of the following:
 - 1) Absorptive Cover: As soon as concrete has sufficient set to permit application without marring concrete surface, install prewetted absorptive cover over entire area of floor.
 - a) Lap edges and ends of absorptive cover not less than 12 inches.
 - b) Maintain absorptive cover water saturated, and in place, for duration of curing period, but not less than seven days.
 - 2) Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive.
 - a) Immediately repair any holes or tears during curing period, using cover material and waterproof tape.
 - b) Cure for not less than seven days.
 - 3) Ponding or Continuous Sprinkling of Water: Maintain concrete surfaces continuously wet for not less than seven days, utilizing one, or a combination of, the following:
 - a) Water.
 - b) Continuous water-fog spray.
- c. Floors to Receive Polished Finish: Contractor has option of the following:
 - 1) Absorptive Cover: As soon as concrete has sufficient set to permit application without marring concrete surface, install prewetted absorptive cover over entire area of floor.
 - a) Lap edges and ends of absorptive cover not less than 12 inches.
 - b) Maintain absorptive cover water saturated, and in place, for duration of curing period, but not less than seven days.
 - 2) Ponding or Continuous Sprinkling of Water: Maintain concrete surfaces continuously wet for not less than seven days, utilizing one, or a combination of, the following:
 - a) Water.
 - b) Continuous water-fog spray.
- d. Floors to Receive Chemical Stain:
 - 1) As soon as concrete has sufficient set to permit application without marring concrete surface, install curing paper over entire area of floor.
 - 2) Install curing paper square to building lines, without wrinkles, and in a single length without end joints.
 - 3) Butt sides of curing paper tight; do not overlap sides of curing paper.
 - 4) Leave curing paper in place for duration of curing period, but not less than 28 days.
- e. Floors to Receive Urethane Flooring:

- 1) As soon as concrete has sufficient set to permit application without marring concrete surface, install prewetted absorptive cover over entire area of floor.
 - 2) Rewet absorptive cover, and cover immediately with polyethylene moisture-retaining cover with edges lapped 6 inches and sealed in place.
 - 3) Secure polyethylene moisture-retaining cover in place to prohibit air from circulating under polyethylene moisture-retaining cover.
 - 4) Leave absorptive cover and polyethylene moisture-retaining cover in place for duration of curing period, but not less than 28 days.
- f. Floors to Receive Curing Compound:
- 1) Apply uniformly in continuous operation by power spray or roller in accordance with manufacturer's written instructions.
 - 2) Recoat areas subjected to heavy rainfall within three hours after initial application.
 - 3) Maintain continuity of coating, and repair damage during curing period.
 - 4) Removal: After curing period has elapsed, remove curing compound without damaging concrete surfaces by method recommended by curing compound manufacturer unless manufacturer certifies curing compound does not interfere with bonding of floor covering used on Project.
- g. Floors to Receive Curing and Sealing Compound:
- 1) Apply uniformly to floors and slabs indicated in a continuous operation by power spray or roller in accordance with manufacturer's written instructions.
 - 2) Recoat areas subjected to heavy rainfall within three hours after initial application.
 - 3) Repeat process 24 hours later, and apply a second coat. Maintain continuity of coating, and repair damage during curing period.

3.11 TOLERANCES

- A. Conform to ACI 117.

3.12 APPLICATION OF LIQUID FLOOR TREATMENTS

- A. Penetrating Liquid Floor Treatment: Prepare, apply, and finish penetrating liquid floor treatment in accordance with manufacturer's written instructions.
1. Remove curing compounds, sealers, oil, dirt, laitance, and other contaminants and complete surface repairs.
 2. Do not apply to concrete that is less than seven days' old.
 3. Apply liquid until surface is saturated, scrubbing into surface until a gel forms; rewet; and repeat brooming or scrubbing.
 4. Rinse with water; remove excess material until surface is dry.
 5. Apply a second coat in a similar manner if surface is rough or porous.

- B. Sealing Coat: Uniformly apply a continuous sealing coat of curing and sealing compound to hardened concrete by power spray or roller in accordance with manufacturer's written instructions.

3.13 JOINT FILLING

- A. Prepare, clean, and install joint filler in accordance with manufacturer's written instructions.
 - 1. Defer joint filling until concrete has aged at least one month(s).
 - 2. Do not fill joints until construction traffic has permanently ceased.
- B. Remove dirt, debris, saw cuttings, curing compounds, and sealers from joints; leave contact faces of joints clean and dry.
- C. Install semirigid joint filler full depth in saw-cut joints and at least 2 inches deep in formed joints.
- D. Overfill joint, and trim joint filler flush with top of joint after hardening.

3.14 CONCRETE SURFACE REPAIRS

- A. Defective Concrete:
 - 1. Repair and patch defective areas when approved by Architect.
 - 2. Remove and replace concrete that cannot be repaired and patched to Architect's approval.
- B. Patching Mortar: Mix dry-pack patching mortar, consisting of 1 part portland cement to 2-1/2 parts fine aggregate passing a No. 16 sieve, using only enough water for handling and placing.
- C. Repairing Formed Surfaces: Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycombs, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning.
 - 1. Immediately after form removal, cut out honeycombs, rock pockets, and voids more than 1/2 inch in any dimension to solid concrete.
 - a. Limit cut depth to 3/4 inch.
 - b. Make edges of cuts perpendicular to concrete surface.
 - c. Clean, dampen with water, and brush-coat holes and voids with bonding agent.
 - d. Fill and compact with patching mortar before bonding agent has dried.
 - e. Fill form-tie voids with patching mortar or cone plugs secured in place with bonding agent.

2. Repair defects on surfaces exposed to view by blending white portland cement and standard portland cement, so that, when dry, patching mortar matches surrounding color.
 - a. Patch a test area at inconspicuous locations to verify mixture and color match before proceeding with patching.
 - b. Compact mortar in place and strike off slightly higher than surrounding surface.
3. Repair defects on concealed formed surfaces that will affect concrete's durability and structural performance as determined by Architect.

D. Repairing Unformed Surfaces:

1. Test unformed surfaces, such as floors and slabs, for finish, and verify surface tolerances specified for each surface.
 - a. Correct low and high areas.
 - b. Test surfaces sloped to drain for trueness of slope and smoothness; use a sloped template.
2. Repair finished surfaces containing surface defects, including spalls, popouts, honeycombs, rock pockets, crazing, and cracks in excess of 0.01 inch wide or that penetrate to reinforcement or completely through unreinforced sections regardless of width, and other objectionable conditions.
3. After concrete has cured at least 14 days, correct high areas by grinding.
4. Correct localized low areas during, or immediately after, completing surface-finishing operations by cutting out low areas and replacing with patching mortar.
 - a. Finish repaired areas to blend into adjacent concrete.
5. Correct other low areas scheduled to receive floor coverings with a repair underlayment.
 - a. Prepare, mix, and apply repair underlayment and primer in accordance with manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.
 - b. Feather edges to match adjacent floor elevations.
6. Correct other low areas scheduled to remain exposed with repair topping.
 - a. Cut out low areas to ensure a minimum repair topping depth of 1/4 inch to match adjacent floor elevations.
 - b. Prepare, mix, and apply repair topping and primer in accordance with manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.
7. Repair defective areas, except random cracks and single holes 1 inch or less in diameter, by cutting out and replacing with fresh concrete.
 - a. Remove defective areas with clean, square cuts, and expose steel reinforcement with at least a 3/4-inch clearance all around.
 - b. Dampen concrete surfaces in contact with patching concrete and apply bonding agent.
 - c. Mix patching concrete of same materials and mixture as original concrete, except without coarse aggregate.
 - d. Place, compact, and finish to blend with adjacent finished concrete.
 - e. Cure in same manner as adjacent concrete.
8. Repair random cracks and single holes 1 inch or less in diameter with patching mortar.

- a. Groove top of cracks and cut out holes to sound concrete, and clean off dust, dirt, and loose particles.
 - b. Dampen cleaned concrete surfaces and apply bonding agent.
 - c. Place patching mortar before bonding agent has dried.
 - d. Compact patching mortar and finish to match adjacent concrete.
 - e. Keep patched area continuously moist for at least 72 hours.
- E. Perform structural repairs of concrete, subject to Architect's approval, using epoxy adhesive and patching mortar.
- F. Repair materials and installation not specified above may be used, subject to Architect's approval.

3.15 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a special inspector to perform field tests and inspections and prepare testing and inspection reports.
- B. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform tests and inspections and to submit reports.
- 1. Testing agency shall be responsible for providing curing container for composite samples on Site and verifying that field-cured composite samples are cured in accordance with ASTM C31/C31M.
 - 2. Testing agency shall immediately report to Architect, Contractor, and concrete manufacturer any failure of Work to comply with Contract Documents.
 - 3. Testing agency shall report results of tests and inspections, in writing, to Owner, Architect, Contractor, and concrete manufacturer within 48 hours of inspections and tests.
 - a. Test reports shall include reporting requirements of ASTM C31/C31M, ASTM C39/C39M, and ACI 301, including the following as applicable to each test and inspection:
 - 1) Project name.
 - 2) Name of testing agency.
 - 3) Names and certification numbers of field and laboratory technicians performing inspections and testing.
 - 4) Name of concrete manufacturer.
 - 5) Date and time of inspection, sampling, and field testing.
 - 6) Date and time of concrete placement.
 - 7) Location in Work of concrete represented by samples.
 - 8) Date and time sample was obtained.
 - 9) Truck and batch ticket numbers.
 - 10) Design compressive strength at 28 days.
 - 11) Concrete mixture designation, proportions, and materials.
 - 12) Field test results.
 - 13) Information on storage and curing of samples before testing, including curing method and maximum and minimum temperatures during initial curing period.

- 14) Type of fracture and compressive break strengths at seven days and 28 days.
- C. Batch Tickets: For each load delivered, submit three copies of batch delivery ticket to testing agency, indicating quantity, mix identification, admixtures, design strength, aggregate size, design air content, design slump at time of batching, and amount of water that can be added at Project site.
- D. Inspections:
1. Headed bolts and studs.
 2. Verification of use of required design mixture.
 3. Concrete placement, including conveying and depositing.
 4. Curing procedures and maintenance of curing temperature.
 5. Verification of concrete strength before removal of shores and forms from beams and slabs.
 6. Batch Plant Inspections: On a random basis, as determined by Architect.
- E. Concrete Tests: Testing of composite samples of fresh concrete obtained in accordance with ASTM C 172/C 172M shall be performed in accordance with the following requirements:
1. Testing Frequency: Obtain one composite sample for each day's pour of each concrete mixture exceeding 5 cu. yd., but less than 25 cu. yd., plus one set for each additional 50 cu. yd. or fraction thereof.
 - a. When frequency of testing provides fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
 2. Slump: ASTM C143/C143M:
 - a. One test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture.
 - b. Perform additional tests when concrete consistency appears to change.
 3. Slump Flow: ASTM C1611/C1611M:
 - a. One test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture.
 - b. Perform additional tests when concrete consistency appears to change.
 4. Air Content: ASTM C231/C231M pressure method, for normal-weight concrete;.
 - a. One test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
 5. Concrete Temperature: ASTM C1064/C1064M:
 - a. One test hourly when air temperature is 40 deg F and below or 80 deg F and above, and one test for each composite sample.
 6. Unit Weight: ASTM C567/C567M fresh unit weight of structural lightweight concrete.
 - a. One test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
 7. Compression Test Specimens: ASTM C31/C31M:

- a. Cast and laboratory cure two sets of two 6-inch by 12-inch cylinder specimens for each composite sample.
 - b. Cast, initial cure, and field cure two sets of two standard cylinder specimens for each composite sample.
 8. Compressive-Strength Tests: ASTM C39/C39M.
 - a. Test one set of two laboratory-cured specimens at seven days and one set of two specimens at 28 days.
 - b. Test one set of two field-cured specimens at seven days and one set of two specimens at 28 days.
 - c. A compressive-strength test shall be the average compressive strength from a set of two specimens obtained from same composite sample and tested at age indicated.
 9. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor shall evaluate operations and provide corrective procedures for protecting and curing in-place concrete.
 10. Strength of each concrete mixture will be satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength, and no compressive-strength test value falls below specified compressive strength by more than 500 psi if specified compressive strength is 5000 psi, or no compressive strength test value is less than 10 percent of specified compressive strength if specified compressive strength is greater than 5000 psi.
 11. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.
 12. Additional Tests:
 - a. Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.
 - b. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C42/C42M or by other methods as directed by Architect.
 - 1) Acceptance criteria for concrete strength shall be in accordance with ACI 301 section 1.6.6.3.
 13. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
 14. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.
- F. Measure floor and slab flatness and levelness in accordance with ASTM E1155 within 24 hours of completion of floor finishing and promptly report test results to Architect.

3.16 PROTECTION

- A. Protect concrete surfaces as follows:
1. Protect from petroleum stains.
 2. Diaper hydraulic equipment used over concrete surfaces.

3. Prohibit vehicles from interior concrete slabs.
4. Prohibit use of pipe-cutting machinery over concrete surfaces.
5. Prohibit placement of steel items on concrete surfaces.
6. Prohibit use of acids or acidic detergents over concrete surfaces.
7. Protect liquid floor treatment from damage and wear during the remainder of construction period. Use protective methods and materials, including temporary covering, recommended in writing by liquid floor treatments installer.
8. Protect concrete surfaces scheduled to receive surface hardener or polished concrete finish using Floor Slab Protective Covering.

END OF SECTION

Special Specification RMA4

Section 051200

HSS Columns/W18x35

SECTION 051200 - STRUCTURAL STEEL FRAMING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Structural steel.
2. Prefabricated building columns.
3. Shear stud connectors.
4. Shrinkage-resistant grout.

B. Related Requirements:

1. Section 051213 "Architecturally Exposed Structural Steel Framing" for additional requirements for architecturally exposed structural steel.
2. Section 053100 "Steel Decking" for field installation of shear stud connectors through deck.
3. Section 055000 "Metal Fabrications" for steel lintels and shelf angles not attached to structural-steel frame miscellaneous steel fabrications and other steel items not defined as structural steel.
4. Section 099113 "Exterior Painting" and Section 099123 "Interior Painting" for painting requirements.
5. Section 133419 "Metal Building Systems" for structural steel.

1.2 DEFINITIONS

- A. Structural Steel: Elements of the structural frame indicated on Drawings and as described in ANSI/AISC 303.
- B. Seismic-Load-Resisting System: Elements of structural-steel frame designated as "SLRS" or along grid lines designated as "SLRS" on Drawings, including columns, beams, and braces and their connections.
- C. Heavy Sections: Rolled and built-up sections as follows:
1. Shapes included in ASTM A6/A6M with flanges thicker than 1-1/2 inches.
 2. Welded built-up members with plates thicker than 2 inches.
 3. Column base plates thicker than 2 inches.
- D. Protected Zone: Structural members or portions of structural members indicated as "protected zone" on Drawings. Connections of structural and nonstructural elements to protected zones are limited.

- E. Demand-Critical Welds: Those welds, the failure of which would result in significant degradation of the strength and stiffness of the seismic-load-resisting system and which are indicated as "demand critical" or "seismic critical" on Drawings.

1.3 COORDINATION

- A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.
- B. Coordinate installation of anchorage items to be embedded in or attached to other construction without delaying the Work. Provide setting diagrams, sheet metal templates, instructions, and directions for installation.

1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.5 ACTION SUBMITTALS

- A. Product Data:
 - 1. Structural-steel materials.
 - 2. High-strength, bolt-nut-washer assemblies.
 - 3. Shear stud connectors.
 - 4. Anchor rods.
 - 5. Threaded rods.
 - 6. Shop primer.
 - 7. Galvanized-steel primer.
 - 8. Etching cleaner.
 - 9. Galvanized repair paint.
 - 10. Shrinkage-resistant grout.
- B. Shop Drawings: Show fabrication of structural-steel components.
 - 1. Include details of cuts, connections, splices, camber, holes, and other pertinent data.
 - 2. Include embedment Drawings.
 - 3. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld. Show backing bars that are to be removed and supplemental fillet welds where backing bars are to remain.
 - 4. Indicate type, size, and length of bolts, distinguishing between shop and field bolts. Identify pretensioned and slip-critical, high-strength bolted connections.
 - 5. Identify members and connections of the seismic-load-resisting system.
 - 6. Indicate locations and dimensions of protected zones.
 - 7. Identify demand-critical welds.

8. Identify members not to be shop primed.

C. Welding Procedure Specifications (WPSs) and Procedure Qualification Records (PQRs): Provide in accordance with AWS D1.1/D1.1M for each welded joint whether prequalified or qualified by testing, including the following:

1. Power source (constant current or constant voltage).
2. Electrode manufacturer and trade name, for demand-critical welds.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer fabricator testing agency.

B. Welding certificates.

C. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers, certifying that shop primers are compatible with topcoats.

D. Mill test reports for structural-steel materials, including chemical and physical properties.

E. Product Test Reports: For the following:

1. Bolts, nuts, and washers, including mechanical properties and chemical analysis.
2. Direct-tension indicators.
3. Tension-control, high-strength, bolt-nut-washer assemblies.
4. Shear stud connectors.

F. Survey of existing conditions.

G. Source quality-control reports.

H. Field quality-control reports.

1.7 QUALITY ASSURANCE

A. Fabricator Qualifications: A qualified fabricator that participates in the AISC Quality Certification Program and is designated an AISC-Certified Plant, Category BU or is accredited by the IAS Fabricator Inspection Program for Structural Steel (Acceptance Criteria 172).

B. Installer Qualifications: A qualified Installer who participates in the AISC Quality Certification Program and is designated an AISC-Certified Erector, Category CSE.

- C. Shop-Painting Applicators: Qualified in accordance with AISC's Sophisticated Paint Endorsement P1 Endorsement P2 Endorsement P3 or to SSPC-QP 3.
- D. Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M.
 - 1. Welders and welding operators performing work on bottom-flange, demand-critical welds shall pass the supplemental welder qualification testing, as required by AWS D1.8/D1.8M. FCAW-S and FCAW-G shall be considered separate processes for welding personnel qualification.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Store materials to permit easy access for inspection and identification. Keep steel members off ground and spaced by using pallets, dunnage, or other supports and spacers. Protect steel members and packaged materials from corrosion and deterioration.
 - 1. Do not store materials on structure in a manner that might cause distortion, damage, or overload to members or supporting structures. Repair or replace damaged materials or structures as directed.
- B. Store fasteners in a protected place in sealed containers with manufacturer's labels intact.
 - 1. Fasteners may be repackaged provided Owner's testing and inspecting agency observes repackaging and seals containers.
 - 2. Clean and relubricate bolts and nuts that become dry or rusty before use.
 - 3. Comply with manufacturers' written recommendations for cleaning and lubricating ASTM F3125/F3125M, Grade F1852 bolt assemblies and for retesting bolt assemblies after lubrication.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Comply with applicable provisions of the following specifications and documents:
 - 1. ANSI/AISC 303.
 - 2. ANSI/AISC 341.
 - 3. ANSI/AISC 360.
 - 4. RCSC's "Specification for Structural Joints Using High-Strength Bolts."
- B. Connection Design Information:

1. Option 1: Connection designs have been completed and connections indicated on the Drawings.

2.2 STRUCTURAL-STEEL MATERIALS

- A. W-Shapes: ASTM A992/A992M ASTM A572/A572M, Grade 50.
- B. Channels, Angles, M, S-Shapes: ASTM A36/A36M.
- C. Plate and Bar: ASTM A36/A36M.
- D. Cold-Formed Hollow Structural Sections: ASTM A500/A500M, Grade B
ASTM A1085/ASTM A1085M structural tubing.
- E. Steel Pipe: ASTM A53/A53M, Type E or Type S, Grade B.
 1. Weight Class: Standard.
 2. Finish: Black except where indicated to be galvanized.
- F. Welding Electrodes: Comply with AWS requirements.

2.3 BOLTS AND CONNECTORS

- A. High-Strength A325 Bolts, Nuts, and Washers: ASTM F3125/F3125M, Grade A325, Type 1, heavy-hex steel structural bolts; ASTM A563, Grade DH, heavy-hex carbon-steel nuts; and ASTM F436/F436M, Type 1, hardened carbon-steel washers; all with plain finish.
 1. Direct-Tension Indicators: ASTM F959/F959M, Type 325-1, compressible-washer type with plain finish.
- B. Zinc-Coated High-Strength A325 Bolts, Nuts, and Washers: ASTM F3125/F3125M, Grade A325, Type 1, heavy-hex steel structural bolts; ASTM A563, Grade DH, heavy-hex carbon-steel nuts; and ASTM F436/F436M, Type 1, hardened carbon-steel washers.
 1. Finish: Hot-dip or mechanically deposited zinc coating.
 2. Direct-Tension Indicators: ASTM F959/F959M, Type 325-1, compressible-washer type with mechanically deposited zinc coating finish.
- C. Shear Stud Connectors: ASTM A108, AISI C-1015 through C-1020, headed-stud type, cold-finished carbon steel; AWS D1.1/D1.1M, Type B.

2.4 RODS

- A. Unheaded Anchor Rods: ASTM F1554, Grade 36.
 - 1. Configuration: Straight.
 - 2. Nuts: ASTM A563hex carbon steel.
 - 3. Plate Washers: ASTM A36/A36M carbon steel.
 - 4. Washers: ASTM F436, Type 1, hardened carbon steel.
 - 5. Finish: Hot-dip zinc coating, ASTM A153/A153M, Class C.
- B. Headed Anchor Rods: ASTM F1554, Grade 36, straight.
 - 1. Nuts: ASTM A563hex carbon steel.
 - 2. Plate Washers: ASTM A36/A36M carbon steel.
 - 3. Washers: ASTM F436, Type 1, hardened carbon steel.
 - 4. Finish: Hot-dip zinc coating, ASTM A153/A153M, Class C.
- C. Threaded Rods: ASTM A36/A36M.
 - 1. Nuts: ASTM A 63hex carbon steel.
 - 2. Washers: ASTM F436, Type 1, hardened carbon steel.
 - 3. Finish: Hot-dip zinc coating, ASTM A153/A153M, Class C.

2.5 PRIMER

- A. Steel Primer:
 - 1. Comply with Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."
 - 2. SSPC-Paint 23, latex primer.
 - 3. Fabricator's standard lead- and chromate-free, nonasphaltic, rust-inhibiting primer complying with MPI#79 and compatible with topcoat.
- B. Galvanized-Steel Primer: MPI#26 MPI#80, MPI#134.
 - 1. Etching Cleaner: MPI#25, for galvanized steel.
 - 2. Galvanizing Repair Paint: MPI#18, MPI#19, or SSPC-Paint 20.

2.6 SHRINKAGE-RESISTANT GROUT

- A. Metallic, Shrinkage-Resistant Grout: ASTM C1107/C1107M, factory-packaged, metallic aggregate grout, mixed with water to consistency suitable for application and a 30-minute working time.
- B. Nonmetallic, Shrinkage-Resistant Grout: ASTM C1107/C1107M, factory-packaged, nonmetallic aggregate grout, noncorrosive and nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

2.7 FABRICATION

- A. Structural Steel: Fabricate and assemble in shop to greatest extent possible. Fabricate in accordance with ANSI/AISC 303 and to ANSI/AISC 360.
 - 1. Camber structural-steel members where indicated.
 - 2. Fabricate beams with rolling camber up.
 - 3. Identify high-strength structural steel in accordance with ASTM A6/A6M and maintain markings until structural-steel framing has been erected.
 - 4. Mark and match-mark materials for field assembly.
 - 5. Complete structural-steel assemblies, including welding of units, before starting shop-priming operations.
- B. Thermal Cutting: Perform thermal cutting by machine to greatest extent possible.
 - 1. Plane thermally cut edges to be welded to comply with requirements in AWS D1.1/D1.1M.
- C. Bolt Holes: Cut, drill, mechanically thermal cut, or punch standard bolt holes perpendicular to metal surfaces.
- D. Finishing: Accurately finish ends of columns and other members transmitting bearing loads.
- E. Cleaning: Clean and prepare steel surfaces that are to remain unpainted in accordance with SSPC-SP 1. SSPC-SP 2. SSPC-SP 3.
- F. Shear Stud Connectors: Prepare steel surfaces as recommended by manufacturer of shear connectors. Weld using automatic end welding of headed-stud shear connectors in accordance with AWS D1.1/D1.1M and manufacturer's written instructions.
- G. Steel Wall-Opening Framing: Select true and straight members for fabricating steel wall-opening framing to be attached to structural-steel frame. Straighten as required to provide uniform, square, and true members in completed wall framing. Build up welded framing, weld exposed joints continuously, and grind smooth.
- H. Welded-Steel Door Frames: Build up welded-steel door frames attached to structural-steel frame. Weld exposed joints continuously and grind smooth. Plug-weld fixed steel bar stops to frames. Secure removable stops to frames with countersunk machine screws, uniformly spaced not more than 10 inches o.c. unless otherwise indicated on Drawings.
- I. Holes: Provide holes required for securing other work to structural steel and for other work to pass through steel members.
 - 1. Cut, drill, or punch holes perpendicular to steel surfaces. Do not thermally cut bolt holes or enlarge holes by burning.

2. Baseplate Holes: Cut, drill, mechanically thermal cut, or punch holes perpendicular to steel surfaces.
3. Weld threaded nuts to framing and other specialty items indicated to receive other work.

2.8 SHOP CONNECTIONS

- A. High-Strength Bolts: Shop install high-strength bolts in accordance with RCSC's "Specification for Structural Joints Using High-Strength Bolts" for type of bolt and type of joint specified.
 1. Joint Type: Snug tightened.
- B. Weld Connections: Comply with AWS D1.1/D1.1M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.
 1. Assemble and weld built-up sections by methods that maintain true alignment of axes without exceeding tolerances in ANSI/AISC 303 for mill material.

2.9 GALVANIZING

- A. Hot-Dip Galvanized Finish: Apply zinc coating by the hot-dip process to structural steel in accordance with ASTM A123/A123M.
 1. Fill vent and drain holes that are exposed in the finished Work unless they function as weep holes, by plugging with zinc solder and filing off smooth.
 2. Galvanize lintels shelf angles and welded door frames attached to structural-steel frame and located in exterior walls.

2.10 SHOP PRIMING

- A. Shop prime steel surfaces, except the following:
 1. Surfaces embedded in concrete or mortar. Extend priming of partially embedded members to a depth of 2 inches.
 2. Surfaces to be field welded.
 3. Surfaces of high-strength bolted, slip-critical connections.
 4. Surfaces to receive sprayed fire-resistive materials (applied fireproofing).
 5. Galvanized surfaces unless indicated to be painted.
 6. Corrosion-resisting (weathering) steel surfaces.
 7. Surfaces enclosed in interior construction.
- B. Surface Preparation of Steel: Clean surfaces to be painted. Remove loose rust and mill scale and spatter, slag, or flux deposits. Prepare surfaces in accordance with the following specifications and standards:

1. SSPC-SP 2.
2. SSPC-SP 3.
3. SSPC-SP 7 (WAB)/NACE WAB-4.
4. SSPC-SP 14 (WAB)/NACE WAB-8.
5. SSPC-SP 11.
6. SSPC-SP 6 (WAB)/NACE WAB-3.
7. SSPC-SP 10 (WAB)/NACE WAB-2.
8. SSPC-SP 5 (WAB)/NACE WAB-1.
9. SSPC-SP 8.

- C. Surface Preparation of Galvanized Steel: Prepare galvanized-steel surfaces for shop priming by thoroughly cleaning steel of grease, dirt, oil, flux, and other foreign matter, and treating with etching cleaner or in accordance with SSPC-SP 16.
- D. Priming: Immediately after surface preparation, apply primer in accordance with manufacturer's written instructions and at rate recommended by SSPC to provide a minimum dry film thickness of 1.5 mils. Use priming methods that result in full coverage of joints, corners, edges, and exposed surfaces.
1. Stripe paint corners, crevices, bolts, welds, and sharp edges.
 2. Apply two coats of shop paint to surfaces that are inaccessible after assembly or erection. Change color of second coat to distinguish it from first.

2.11 SOURCE QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform shop tests and inspections.
1. Allow testing agency access to places where structural-steel work is being fabricated or produced to perform tests and inspections.
 2. Bolted Connections: Inspect and test shop-bolted connections in accordance with RCSC's "Specification for Structural Joints Using High-Strength Bolts."
 3. Welded Connections: Visually inspect shop-welded connections in accordance with AWS D1.1/D1.1M and the following inspection procedures, at testing agency's option:
 - a. Liquid Penetrant Inspection: ASTM E165/E165M.
 - b. Magnetic Particle Inspection: ASTM E709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration are not accepted.
 - c. Ultrasonic Inspection: ASTM E164.
 - d. Radiographic Inspection: ASTM E94/E94M.
 4. In addition to visual inspection, test and inspect shop-welded shear stud connectors in accordance with requirements in AWS D1.1/D1.1M for stud welding and as follows:
 - a. Perform bend tests if visual inspections reveal either a less-than-continuous 360-degree flash or welding repairs to any shear stud connector.

- b. Conduct tests in accordance with requirements in AWS D1.1/D1.1M on additional shear stud connectors if weld fracture occurs on shear stud connectors already tested.
- 5. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify, with certified steel erector present, elevations of concrete- and masonry-bearing surfaces and locations of anchor rods, bearing plates, and other embedments for compliance with requirements.
 - 1. Prepare a certified survey of existing conditions. Include bearing surfaces, anchor rods, bearing plates, and other embedments showing dimensions, locations, angles, and elevations.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Provide temporary shores, guys, braces, and other supports during erection to keep structural steel secure, plumb, and in alignment against temporary construction loads and loads equal in intensity to design loads. Remove temporary supports when permanent structural steel, connections, and bracing are in place unless otherwise indicated on Drawings.
 - 1. Do not remove temporary shoring supporting composite deck construction and structural-steel framing until cast-in-place concrete has attained its design compressive strength.

3.3 ERECTION

- A. Set structural steel accurately in locations and to elevations indicated and in accordance with ANSI/AISC 303 and ANSI/AISC 360.
- B. Baseplates Bearing Plates and Leveling Plates: Clean concrete- and masonry-bearing surfaces of bond-reducing materials, and roughen surfaces prior to setting plates. Clean bottom surface of plates.
 - 1. Set plates for structural members on wedges, shims, or setting nuts as required.
 - 2. Weld plate washers to top of baseplate.
 - 3. Snug-tighten anchor rods after supported members have been positioned and plumbed. Do not remove wedges or shims but, if protruding, cut off flush with edge of plate before packing with grout.

4. Promptly pack shrinkage-resistant grout solidly between bearing surfaces and plates, so no voids remain. Neatly finish exposed surfaces; protect grout and allow to cure. Comply with manufacturer's written installation instructions for grouting.
- C. Maintain erection tolerances of structural steel within ANSI/AISC 303.
 - D. Align and adjust various members that form part of complete frame or structure before permanently fastening. Before assembly, clean bearing surfaces and other surfaces that are in permanent contact with members. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.
 1. Level and plumb individual members of structure. Slope roof framing members to slopes indicated on Drawings.
 2. Make allowances for difference between temperature at time of erection and mean temperature when structure is completed and in service.
 - E. Splice members only where indicated.
 - F. Do not use thermal cutting during erection.
 - G. Do not enlarge unfair holes in members by burning or using drift pins. Ream holes that must be enlarged to admit bolts.

3.4 FIELD CONNECTIONS

- A. High-Strength Bolts: Install high-strength bolts in accordance with RCSC's "Specification for Structural Joints Using High-Strength Bolts" for bolt and joint type specified.
 1. Joint Type: Snug tightened.
- B. Weld Connections: Comply with AWS D1.1/D1.1M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.
 1. Comply with ANSI/AISC 303 and ANSI/AISC 360 for bearing, alignment, adequacy of temporary connections, and removal of paint on surfaces adjacent to field welds.
 2. Remove backing bars or runoff tabs, back gouge, and grind steel smooth.
 3. Assemble and weld built-up sections by methods that maintain true alignment of axes without exceeding tolerances in ANSI/AISC 303 for mill material.

3.5 PREFABRICATED BUILDING COLUMNS

- A. Install prefabricated building columns to comply with ANSI/AISC 360, manufacturer's written recommendations, and requirements of testing and inspecting agency that apply to the fire-resistance rating indicated.

3.6 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a special inspector to perform the following special inspections:
 - 1. Verify structural-steel materials and inspect steel frame joint details.
 - 2. Verify weld materials and inspect welds.
 - 3. Verify connection materials and inspect high-strength bolted connections.
- B. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
 - 1. Bolted Connections: Inspect and test bolted connections in accordance with RCSC's "Specification for Structural Joints Using High-Strength Bolts."
 - 2. Welded Connections: Visually inspect field welds in accordance with AWS D1.1/D1.1M.
 - a. In addition to visual inspection, test and inspect field welds in accordance with AWS D1.1/D1.1M and the following inspection procedures, at testing agency's option:
 - 1) Liquid Penetrant Inspection: ASTM E165/E165M.
 - 2) Magnetic Particle Inspection: ASTM E709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration are not accepted.
 - 3) Ultrasonic Inspection: ASTM E164.
 - 4) Radiographic Inspection: ASTM E94/E94M.

3.7 PROTECTION

- A. Galvanized Surfaces: Clean areas where galvanizing is damaged or missing, and repair galvanizing to comply with ASTM A780/A780M.
- B. Touchup Painting: Immediately after erection, clean exposed areas where primer is damaged or missing, and paint with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
 - 1. Clean and prepare surfaces by SSPC-SP 2 hand-tool cleaning or SSPC-SP 3 power-tool cleaning.
- C. Touchup Painting: Cleaning and touchup painting are specified in Section 099113 "Exterior Painting." Section 099123 "Interior Painting."

- D. Touchup Priming: Cleaning and touchup priming are specified in Section 099600 "High-Performance Coatings."

END OF SECTION

Special Specification RMA5

Section 053100

Composite Deck

SECTION 053100 - STEEL DECKING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Roof deck.
2. Composite floor deck.

B. Related Requirements:

1. Section 033000 "Cast-in-Place Concrete" for normal-weight and lightweight structural concrete fill over steel deck.
2. Section 051200 "Structural Steel Framing" for shop- and field-welded shear connectors.
3. Section 055000 "Metal Fabrications" for framing deck openings with miscellaneous steel shapes.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Roof deck.
2. Composite floor deck.

B. Shop Drawings:

1. Include layout and types of deck panels, anchorage details, reinforcing channels, pans, cut deck openings, special jointing, accessories, and attachments to other construction.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Product Certificates: For each type of steel deck.

C. Test and Evaluation Reports:

1. Product Test Reports: For tests performed by a qualified testing agency, indicating that each of the following complies with requirements:
 - a. Power-actuated mechanical fasteners.
2. Research Reports: For steel deck, from ICC-ES showing compliance with the building code.

- D. Field Quality-Control Submittals:
 - 1. Field quality-control reports.
- E. Qualification Statements: For welding personnel and testing agency.

1.4 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel in accordance with SDI QA/QC and the following welding codes:
 - 1. AWS D1.1/D1.1M.
 - 2. AWS D1.3/D1.3M.
- B. FM Approvals' RoofNav Listing: Provide steel roof deck evaluated by FM Approvals and listed in its "RoofNav" for Class 1 fire rating and Class 1-90 windstorm ratings. Identify materials with FM Approvals Certification markings.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Protect steel deck from corrosion, deformation, and other damage during delivery, storage, and handling.
- B. Store products in accordance with SDI MOC3. Stack steel deck on platforms or pallets and slope to provide drainage. Protect with a waterproof covering and ventilate to avoid condensation.
 - 1. Protect and ventilate acoustical cellular roof deck with factory-installed insulation to maintain insulation free of moisture.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. AISI Specifications: Comply with calculated structural characteristics of steel deck in accordance with AISI S100.
- B. Fire-Resistance Ratings: Comply with ASTM E119; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Indicate design designations from UL's "Fire Resistance Directory" or from listings of another qualified testing agency.
- C. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. [ASC Steel Deck; ASC Profiles, LLC.](#)
2. [Canam Buildings US Inc.; Canam Group Inc.](#)
3. [Cordeck.](#)
4. [DACS, Inc.](#)
5. [Epic Metals Corporation.](#)
6. [Marlyn Steel Decks, Inc.](#)
7. [Miami Metal Deck.](#)
8. [New Millennium Building Systems, LLC.](#)
9. [OEG Building Materials Inc.](#)
10. [Roof Deck, Inc.](#)
11. [Tristate Decking, Inc.](#)
12. [Valley Joist.](#)
13. [Verco Decking, Inc.; a Nucor company.](#)
14. [Vulcraft Group; Division of Nucor Corp.](#)
15. [Vulcraft/Verco Group; a division of Nucor Corp.](#)

D. Fabrication of Roof Deck: Fabricate panels, without top-flange stiffening grooves, to comply with SDI RD and with the following:

1. Prime-Painted Steel Sheet: ASTM A1008/A1008M, Structural Steel (SS), Grade 33 minimum, shop primed with manufacturer's standard baked-on, rust-inhibitive primer.
 - a. Color: Manufacturer's standard.
2. Galvanized-Steel Sheet: ASTM A653/A653M, Structural Steel (SS), Grade 33, G60 zinc coating.
3. Galvanized- and Shop-Primed Steel Sheet: ASTM A653/A653M, Structural Steel (SS), Grade 33, G60 zinc coating; cleaned, pretreated, and primed with manufacturer's standard baked-on, rust-inhibitive primer.
 - a. Color: Manufacturer's standard.
4. Aluminum-Zinc-Alloy-Coated Steel Sheet: ASTM A792/A792M, Structural Steel (SS), Grade 33 minimum, AZ50 aluminum-zinc-alloy coating.
5. Deck Profile: As indicated.
6. Profile Depth: As indicated.
7. Design Uncoated-Steel Thickness: As indicated.
8. Design Uncoated-Steel Thicknesses; Deck Unit/Bottom Plate: As indicated.
9. Span Condition: As indicated.
10. Side Laps: Overlapped or interlocking seam at Contractor's option.

2.2 COMPOSITE FLOOR DECK

A. [Manufacturers:](#) Subject to compliance with requirements, provide products by one of the following:

1. [ASC Steel Deck; ASC Profiles, LLC.](#)
2. [Canam Buildings US Inc.; Canam Group Inc.](#)
3. [Cordeck.](#)

4. [DACS, Inc.](#)
5. [Epic Metals Corporation.](#)
6. [Marlyn Steel Decks, Inc.](#)
7. [Miami Metal Deck.](#)
8. [New Millennium Building Systems, LLC.](#)
9. [OEG Building Materials Inc.](#)
10. [Roof Deck, Inc.](#)
11. [Tristate Decking, Inc.](#)
12. [Verco Decking, Inc.; a Nucor company.](#)
13. [Vulcraft Group; Division of Nucor Corp.](#)
14. [Vulcraft/Verco Group; a division of Nucor Corp.](#)

B. Fabrication of Composite Floor Deck: Fabricate panels, with integrally embossed or raised pattern ribs and interlocking side laps, to comply with SDI C, with the minimum section properties indicated, and with the following:

1. Prime-Painted Steel Sheet: ASTM A1008/A1008M, Structural Steel (SS), Grade 33 minimum, with top surface phosphatized and unpainted and underside surface shop primed with manufacturers' standard gray or white baked-on, rust-inhibitive primer.
2. Galvanized-Steel Sheet: ASTM A653/A653M, Structural Steel (SS), Grade 33, G60 zinc coating.
3. Galvanized- and Shop-Primed Steel Sheet: ASTM A653/A653M, Structural Steel (SS), Grade 33, G60 zinc coating; with unpainted top surface and cleaned and pretreated bottom surface primed with manufacturer's standard gray baked-on, rust-inhibitive primer.
4. Profile Depth: As indicated.
5. Design Uncoated-Steel Thickness: 0.0358 inch.
6. Span Condition: As indicated.

2.3 ACCESSORIES

- A. Provide manufacturer's standard accessory materials for deck that comply with requirements indicated.
- B. Mechanical Fasteners: Corrosion-resistant, low-velocity, power-actuated or pneumatically driven carbon-steel fasteners; or self-drilling, self-threading screws.
- C. Side-Lap Fasteners: Corrosion-resistant, hexagonal washer head; self-drilling, carbon-steel screws, No. 10 minimum diameter.
- D. Flexible Closure Strips: Vulcanized, closed-cell, synthetic rubber.
- E. Miscellaneous Sheet Metal Deck Accessories: Steel sheet, minimum yield strength of 33,000 psi, not less than 0.0359-inch design uncoated thickness, of same material and finish as deck; of profile indicated or required for application.
- F. Pour Stops and Girder Fillers: Steel sheet, minimum yield strength of 33,000 psi, of same material and finish as deck, and of thickness and profile recommended by SDI standards for overhang and slab depth.

- G. Column Closures, End Closures, Z-Closures, and Cover Plates: Steel sheet, of same material, finish, and thickness as deck unless otherwise indicated.
- H. Piercing Hanger Tabs: Piercing steel sheet hanger attachment devices for use with floor deck.
- I. Weld Washers: Uncoated steel sheet, shaped to fit deck rib, 0.0598 inch thick, with factory-punched hole of 3/8-inch minimum diameter.
- J. Shear Stud Connectors: ASTM A108, AISI C-1015 through C-1020, headed-stud type, cold-finished carbon steel; AWS D1.1/D1.1M, Type B.
- K. Flat Sump Plates: Single-piece steel sheet, 0.0747 inch thick, of same material and finish as deck. For drains, cut holes in the field.
- L. Recessed Sump Pans: Single-piece steel sheet, 0.0747 inch thick, of same material and finish as deck, with 3-inch- wide flanges and level recessed pans of 1-1/2-inch minimum depth. For drains, cut holes in the field.
- M. Galvanizing Repair Paint: ASTM A780/A780M SSPC-Paint 20 or MIL-P-21035B, with dry film containing a minimum of 94 percent zinc dust by weight.
- N. Repair Paint: Manufacturer's standard rust-inhibitive primer of same color as primer.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine supporting frame and field conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Install deck panels and accessories in accordance with SDI C, SDI NC, and SDI RD, as applicable; manufacturer's written instructions; and requirements in this Section.
- B. Install temporary shoring before placing deck panels if required to meet deflection limitations.
- C. Locate deck bundles to prevent overloading of supporting members.
- D. Place deck panels on supporting frame and adjust to final position with ends accurately aligned and bearing on supporting frame before being permanently fastened. Do not stretch or contract side-lap interlocks.
 - 1. Align cellular deck panels over full length of cell runs and align cells at ends of abutting panels.

- E. Place deck panels flat and square and fasten to supporting frame without warp or deflection.
- F. Cut and neatly fit deck panels and accessories around openings and other work projecting through or adjacent to deck.
- G. Provide additional reinforcement and closure pieces at openings as required for strength, continuity of deck, and support of other work.
- H. Comply with AWS requirements and procedures for manual shielded metal arc welding, appearance and quality of welds, and methods used for correcting welding work.
- I. Mechanical fasteners may be used in lieu of welding to fasten deck. Locate mechanical fasteners and install in accordance with deck manufacturer's written instructions.
- J. Shear Stud Connectors: Prepare steel surfaces as recommended by manufacturer of shear connectors. Weld using end welding of headed-stud shear connectors in accordance with AWS D1.1/D1.1M and manufacturer's written instructions.

3.3 INSTALLATION OF ROOF DECK

- A. Fasten roof-deck panels to steel supporting members by arc spot (puddle) welds of the surface diameter indicated or arc seam welds with an equal perimeter that is not less than 1-1/2 inches long, and as follows:
 - 1. Weld Diameter: 5/8 inch, nominal.
 - 2. Weld Spacing: Weld edge and interior ribs of deck units with a minimum of two welds per deck unit at each support. Space welds 12 inches apart in Zone 1 and 6 inches apart in Zones 2 and 3, based on roof-area definitions in FM Global Loss Prevention Data Sheet 1-28.
 - 3. Weld Washers: Install weld washers at each weld location.
- B. Side-Lap and Perimeter Edge Fastening: Fasten side laps and perimeter edges of panels between supports, at intervals not exceeding the lesser of one-half of the span or 18 inches, and as follows:
 - 1. Mechanically fasten with self-drilling, No. 10 diameter or larger, carbon-steel screws.
 - 2. Mechanically clinch or button punch.
 - 3. Fasten with a minimum of 1-1/2-inch- long welds.
- C. End Bearing: Install deck ends over supporting frame with a minimum end bearing of 1-1/2 inches, with end joints as follows:
 - 1. End Joints: Lapped 2 inches minimum.
- D. Roof Sump Pans and Sump Plates: Install over openings provided in roof deck and weld flanges to top of deck. Space welds not more than 12 inches apart with at least one weld at each corner.
 - 1. Install reinforcing channels or zees in ribs to span between supports and weld or mechanically fasten.

- E. Miscellaneous Roof-Deck Accessories: Install ridge and valley plates, finish strips, end closures, and reinforcing channels in accordance with deck manufacturer's written instructions. Weld or mechanically fasten to substrate to provide a complete deck installation.
 - 1. Weld cover plates at changes in direction of roof-deck panels unless otherwise indicated.
- F. Flexible Closure Strips: Install flexible closure strips over partitions, walls, and where indicated. Install with adhesive in accordance with manufacturer's written instructions to ensure complete closure.

3.4 INSTALLATION OF FLOOR DECK

- A. Fasten floor-deck panels to steel supporting members by arc spot (puddle) welds of the surface diameter indicated and as follows:
 - 1. Weld Diameter: 5/8 inch, nominal.
 - 2. Weld Spacing:
 - a. Weld edge ribs of panels at each support. Space additional welds an average of 16 inches apart, but not more than 18 inches apart.
 - b. Space and locate welds as indicated.
 - 3. Weld Washers: Install weld washers at each weld location.
- B. Side-Lap and Perimeter Edge Fastening: Fasten side laps and perimeter edges of panels between supports, at intervals not exceeding the lesser of one-half of the span or 36 inches, and as follows:
 - 1. Mechanically fasten with self-drilling, No. 10 diameter or larger, carbon-steel screws.
 - 2. Mechanically clinch or button punch.
 - 3. Fasten with a minimum of 1-1/2-inch- long welds.
- C. End Bearing: Install deck ends over supporting frame with a minimum end bearing of 1-1/2 inches, with end joints as follows:
 - 1. End Joints: Lapped or butted at Contractor's option.
- D. Pour Stops and Girder Fillers: Weld steel sheet pour stops and girder fillers to supporting structure in accordance with SDI recommendations unless otherwise indicated.
- E. Floor-Deck Closures: Weld steel sheet column closures, cell closures, and Z-closures to deck, in accordance with SDI recommendations, to provide tight-fitting closures at open ends of ribs and sides of deck.
- F. Install piercing hanger tabs at 14 inches apart in both directions, within 9 inches of walls at ends, and not more than 12 inches from walls at sides unless otherwise indicated.

3.5 REPAIR

- A. Galvanizing Repairs: Prepare and repair damaged galvanized coatings on both surfaces of deck with galvanized repair paint in accordance with ASTM A780/A780M and manufacturer's written instructions.
- B. Repair Painting:
 - 1. Wire brush and clean rust spots, welds, and abraded areas on both surfaces of prime-painted deck immediately after installation, and apply repair paint.
 - 2. Apply repair paint, of same color as adjacent shop-primed deck, to bottom surfaces of deck exposed to view.
 - 3. Wire brushing, cleaning, and repair painting of bottom deck surfaces are included in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."
 - 4. Wire brushing, cleaning, and repair painting of rust spots, welds, and abraded areas of both deck surfaces are included in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Tests and Inspections:
 - 1. Special inspections and qualification of welding special inspectors for cold-formed steel floor and roof deck in accordance with quality-assurance inspection requirements of SDI QA/QC.
 - a. Field welds will be subject to inspection.
 - 2. Steel decking will be considered defective if it does not pass tests and inspections.
 - 3. Shear Stud Connectors: In addition to visual inspection, test and inspect field-welded shear connectors in accordance with requirements in AWS D1.1/D1.1M for stud welding and as follows:
 - a. Perform bend tests if visual inspections reveal either a less-than-continuous 360-degree flash or welding repairs to any shear connector.
 - b. Conduct tests in accordance with requirements in AWS D1.1/D1.1M on additional shear connectors if weld fracture occurs on shear connectors that are already tested.
- C. Prepare test and inspection reports.

END OF SECTION 053100

Special Specification RMA6

Section 055113

Metal Pan Stairs

SECTION 055113 - METAL PAN STAIRS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

1. Preambled steel stairs with **concrete-filled** treads.
2. **Steel tube** railings and guards attached to metal stairs.
3. **Steel tube** handrails attached to walls adjacent to metal stairs.
4. Railing gates at the level of exit discharge.

1.3 COORDINATION

- A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written instructions to ensure that shop primers and topcoats are compatible with one another.
- B. Coordinate installation of anchorages for metal stairs, **railings, and guards**.
 1. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, **blocking for attachment of wall-mounted handrails**, and items with integral anchors, that are to be embedded in concrete or masonry.
 2. Deliver such items to Project site in time for installation.
- C. Coordinate locations of hanger rods and struts with other work so they do not encroach on required stair width and are within fire-resistance-rated stair enclosure.
- D. Schedule installation of railings and guards so wall attachments are made only to completed walls.
 1. Do not support railings and guards temporarily by any means that do not satisfy structural performance requirements.

1.4 ACTION SUBMITTALS

- A. Product Data: For metal pan stairs and the following:

1. Abrasive nosings.
2. Shop primer products.
3. Nonslip-aggregate concrete finish.
4. Handrail wall brackets.
5. Grout.

B. Shop Drawings:

1. Include plans, elevations, sections, details, and attachments to other work.
2. Indicate sizes of metal sections, thickness of metals, profiles, holes, and field joints.
3. Include plan at each level.
4. Indicate locations of anchors, weld plates, and blocking for attachment of wall-mounted handrails.

C. Samples for Verification: For each type and finish of tread.

D. Delegated-Design Submittal: For stairs, **railings and guards**, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For professional engineer's experience with providing delegated-design engineering services of the kind indicated, including documentation that engineer is licensed in the state of Texas in which Project is located.
- B. Welding certificates.
- C. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers, certifying that shop primers are compatible with topcoats.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Fabricator of products.
- B. Welding Qualifications: Qualify procedures and personnel according to the following:
1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 2. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store materials to permit easy access for inspection and identification.

1. Keep steel members off ground and spaced by using pallets, dunnage, or other supports and spacers.
2. Protect steel members and packaged materials from corrosion and deterioration.
3. Do not store materials on structure in a manner that might cause distortion, damage, or overload to members or supporting structures.
 - a. Repair or replace damaged materials or structures as directed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design stairs, **railings and guards**, including attachment to building construction.
- B. Structural Performance of Stairs: Metal stairs shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
 1. Uniform Load: 100 lbf/sq. ft. (4.79 kN/sq. m).
 2. Concentrated Load: 300 lbf (1.33 kN) applied on an area of 4 sq. in. (2580 sq. mm).
 3. Uniform and concentrated loads need not be assumed to act concurrently.
 4. Stair Framing: Capable of withstanding stresses resulting from railing and guard loads in addition to loads specified above.
 5. Limit deflection of treads, platforms, and framing members to L/360 or 1/4 inch (6.4 mm), whichever is less.
- C. Structural Performance of Railings and Guards: Railings and guards, including attachment to building construction, shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
 1. Handrails and Top Rails of Guards:
 - a. Uniform load of 50 lbf/ft. (0.73 kN/m) applied in any direction.
 - b. Concentrated load of 200 lbf (0.89 kN) applied in any direction.
 - c. Uniform and concentrated loads need not be assumed to act concurrently.
 2. Infill of Guards:
 - a. Concentrated load of 50 lbf (0.22 kN) applied horizontally on an area of 1 sq. ft. (0.093 sq. m).
 - b. Infill load and other loads need not be assumed to act concurrently.
 3. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 - a. Temperature Change: **120 deg F (67 deg C), ambient; material surfaces.**

- D. Seismic Performance of Stairs: Metal stairs shall withstand the effects of earthquake motions determined according to **ASCE/SEI 7**.

2.2 METALS

- A. Metal Surfaces: Provide materials with smooth, flat surfaces unless otherwise indicated. For components exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.
- B. Steel Plates, Shapes, and Bars: ASTM A36/A36M.
- C. Steel Tubing for Railings and Guards: ASTM A500/A500M (cold formed) or ASTM A513/A513M.
1. Provide galvanized finish for exterior installations and where indicated.
- D. Steel Pipe for Railings and Guards: ASTM A53/A53M, Type F or Type S, Grade A, Standard Weight (Schedule 40), unless another grade and weight are required by structural loads.
1. Provide galvanized finish for exterior installations and where indicated.
- E. Uncoated, Cold-Rolled Steel Sheet: ASTM A1008/A1008M, either commercial steel, Type B, or structural steel, Grade 25 (Grade 170), unless another grade is required by design loads.
- F. Uncoated, Hot-Rolled Steel Sheet: ASTM A1011/A1011M, either commercial steel, Type B, or structural steel, Grade 30 (Grade 205), unless another grade is required by design loads.
- G. Galvanized-Steel Sheet: ASTM A653/A653M, G90 (Z275) coating, either commercial steel, Type B, or structural steel, Grade 33 (Grade 230), unless another grade is required by design loads.

2.3 ABRASIVE NOSINGS

- A. Cast-Metal Units: Cast iron, with an integral abrasive, as-cast finish consisting of aluminum oxide, silicon carbide, or a combination of both. Fabricate units in lengths necessary to accurately fit openings or conditions
1. Configuration: Cross-hatched units, 3 inches (75 mm) wide without lip.
2.
3. Provide ribbed units, with abrasive filler strips projecting 1/16 inch (1.5 mm) above aluminum extrusion.
4. Provide solid-abrasive units without ribs.
5. Nosings: Square-back units, 3 inches (75 mm) wide, without lip.
6. Nosings: Two-piece units, 3 inches (75 mm) wide, with subchannel for casting into concrete.

- B. Provide anchors for embedding units in concrete, either integral or applied to units, as standard with manufacturer.
- C. Apply bituminous paint to concealed surfaces of cast-metal units set into concrete.
- D. Apply clear lacquer to concealed surfaces of extruded units set into concrete.

2.4 FASTENERS

- A. General: Provide **zinc-plated fasteners with coating complying with ASTM B633 or ASTM F1941/F1941M, Class Fe/Zn 5** where built into exterior walls.
 - 1. Select fasteners for type, grade, and class required.
- B. Fasteners for Anchoring Railings and Guards to Other Construction: Select fasteners of type, grade, and class required to produce connections suitable for anchoring railings and guards to other types of construction indicated **and capable of withstanding design loads**].
- C. Bolts and Nuts: Regular hexagon-head bolts, ASTM A307, Grade A; with hex nuts, ASTM A563 (ASTM A563M); and, where indicated, flat washers.
- D. Anchor Bolts: ASTM F1554, Grade 36, of dimensions indicated; with nuts, ASTM A563 (ASTM A563M); and, where indicated, flat washers.
 - 1. Provide mechanically deposited or hot-dip, zinc-coated anchor bolts for **exterior stairs stairs indicated to be galvanized**.
- E. Post-Installed Anchors: **Torque-controlled expansion anchors** capable of sustaining, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing according to ASTM E488/E488M, conducted by a qualified independent testing agency.
 - 1. Material for Interior Locations: Carbon-steel components zinc plated to comply with ASTM B633 or ASTM F1941/F1941M, Class Fe/Zn 5, unless otherwise indicated.
 - 2. Material for Exterior Locations and Where Stainless Steel Is Indicated: Alloy Group 1 (A1) stainless-steel bolts, ASTM F593, and nuts, ASTM F594 (ASTM F836M).

2.5 MISCELLANEOUS MATERIALS

- A. Handrail Wall Brackets: **Cast nickel-silver**, center of rail 2-1/2 inches (63.5 mm) from face of wall.
- B. Welding Electrodes: Comply with AWS requirements.
- C. Shop Primers: Provide primers that comply with **Interior Painting**.

- D. Universal Shop Primer: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with MPI#79 and compatible with topcoat.
 - 1. Use primer containing pigments that make it easily distinguishable from zinc-rich primer.
- E. Zinc-Rich Primer: Comply with SSPC-Paint 20, **Type I-A**, and compatible with topcoat.
- F. Shop Primer for Galvanized Steel: Primer formulated for exterior use over zinc-coated metal and compatible with finish system indicated.
- G. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 ASTM A780/A780M and compatible with paints specified to be used over it.
- H. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D1187/D1187M.
- I. Nonmetallic, Shrinkage-Resistant Grout: ASTM C1107/C1107M, factory-packaged, nonmetallic aggregate grout; recommended by manufacturer for exterior use; noncorrosive and nonstaining; mixed with water to consistency suitable for application and a 30-minute working time.

2.6 FABRICATION, GENERAL

- A. Provide complete stair assemblies, including metal framing, hangers, struts, **railings and guards**, clips, brackets, bearing plates, and other components necessary to support and anchor stairs and platforms on supporting structure.
 - 1. Join components by welding unless otherwise indicated.
 - 2. Use connections that maintain structural value of joined pieces.
- B. Assemble stairs, **railings, and guards** in shop to greatest extent possible.
 - 1. Disassemble units only as necessary for shipping and handling limitations.
 - 2. Clearly mark units for reassembly and coordinated installation.
- C. Cut, drill, and punch metals cleanly and accurately.
 - 1. Remove burrs and ease edges to a radius of approximately 1/32 inch (1 mm) unless otherwise indicated.
 - 2. Remove sharp or rough areas on exposed surfaces.
- D. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
- E. Form exposed work with accurate angles and surfaces and straight edges.
- F. Weld connections to comply with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 2. Obtain fusion without undercut or overlap.
 3. Remove welding flux immediately.
 4. Weld exposed corners and seams continuously unless otherwise indicated.
 5. At exposed connections, finish exposed welds to comply with NOMMA's "Voluntary Joint Finish Standards" for **Finish #2 - Completely sanded joint with some undercutting and pinholes okay removed.**
- G. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible.
1. Where exposed fasteners are required, use Phillips flat-head (countersunk) screws or bolts unless otherwise indicated.
 2. Locate joints where least conspicuous.
 3. Fabricate joints that will be exposed to weather in a manner to exclude water.
 4. Provide weep holes where water may accumulate internally.

2.7 FABRICATION OF STEEL-FRAMED STAIRS

- A. NAAMM Stair Standard: Comply with NAAMM AMP 510, "Metal Stairs Manual," for **Commercial** Class, unless more stringent requirements are indicated.
- B. Stair Framing:
1. Fabricate stringers **of steel plates.**
 - a. Stringer Size: **As required to comply with "Performance Requirements" Article As indicated on Drawings.**
 - b. Provide closures for exposed ends of channel and rectangular tube stringers.
 - c. Finish: **Galvanized.**
 2. Construct platforms of steel **plate** headers and miscellaneous framing members **as required to comply with "Performance Requirements".**
 - a. Provide closures for exposed ends of channel and rectangular tube framing.
 - b. Finish: **Galvanized.**
 3. **Bolt** stringers to headers; **bolt** framing members to stringers and headers. **Fabricate and join so bolts are not exposed on finished surfaces.**
 - a. Locate hanger rods and struts where they do not encroach on required stair width and are within the fire-resistance-rated stair enclosure.
- C. Metal Pan Stairs: Form risers, subread pans, and subplatforms to configurations shown from steel sheet of thickness needed to comply with performance requirements, but not less than 0.067 inch (1.7 mm).

1. Fabricate treads and landing subplatforms of exterior stairs so finished walking surfaces slope to drain.
 2. Steel Sheet: Uncoated, **cold**-rolled steel sheet **unless indicated**.
 3. Steel Sheet: Galvanized-steel sheet, **where indicated**.
 4. Directly weld metal pans to stringers; locate welds on top of subtreads where they will be concealed by concrete fill. Do not weld risers to stringers.
 5. Attach risers and subtreads to stringers with brackets made of steel angles or bars. Weld brackets to stringers and attach metal pans to brackets by welding, riveting, or bolting.
 6. Shape metal pans to include nosing integral with riser.
 7. Attach abrasive nosings to risers.
 8. At Contractor's option, provide stair assemblies with metal pan subtreads filled with reinforced concrete during fabrication.
 9. Provide epoxy-resin-filled treads, reinforced with glass fibers, with non-slip-concrete aggregate finish to tread surface.
 10. Provide subplatforms of configuration indicated or, if not indicated, the same as subtreads. Weld subplatforms to platform framing.
 - a. Smooth Soffit Construction: Construct subplatforms with flat metal under surfaces to produce smooth soffits.
- D. Abrasive-Coating-Finished, Formed-Metal Stairs: Form risers, treads, and platforms to configurations shown from steel sheet of thickness needed to comply with performance requirements, but not less than 0.097 inch (2.5 mm).
1. Steel Sheet: Uncoated, hot-rolled steel sheet unless otherwise indicated.
 2. Directly weld risers and treads to stringers; locate welds on underside of stairs.
 3. Provide platforms of configuration indicated or, if not indicated, the same as treads. Weld platforms to platform framing.
 4. Finish tread and platform surfaces with manufacturer's standard epoxy-bonded abrasive finish.

2.8 FABRICATION OF STAIR RAILINGS AND GUARDS

- A. Comply with applicable requirements in **Section 055213 "Pipe and Tube Railings"**.
- B. Fabricate railings and guards to comply with requirements indicated for design, dimensions, details, finish, and member sizes, including wall thickness of member, post spacings, wall bracket spacing, and anchorage, but not less than that needed to withstand indicated loads.
1. Rails and Posts: **1-1/2-inch- (38-mm-) square** top and bottom rails and 1-1/2-inch- (38-mm-) square posts.
 2. Picket Infill: **3/4-inch- (19-mm-) square** pickets spaced to prohibit the passage of a 4-inch (100-mm) diameter sphere.
 3. Intermediate Rails Infill: **1-5/8-inch- (41-mm-) diameter, 1-inch- (38-mm-) square** intermediate rails spaced less than **12 inches (305 mm) 21 inch (533 mm)** clear.
- C. Welded Connections: Fabricate railings and guards with welded connections.

1. Fabricate connections that are exposed to weather in a manner that excludes water.
 - a. Provide weep holes where water may accumulate internally.
 2. Cope components at connections to provide close fit, or use fittings designed for this purpose.
 3. Weld all around at connections, including at fittings.
 4. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 5. Obtain fusion without undercut or overlap.
 6. Remove flux immediately.
 7. Finish welds to comply with NOMMA's "Voluntary Joint Finish Standards" for **#2 - Completely sanded joint, some undercutting and pinholes are okay** as shown in NAAMM AMP 521.
- D. Form changes in direction of railings and guards as follows:
1. By radius bends of radius indicated **or by inserting prefabricated elbow fittings of radius indicated.**
- E. For changes in direction made by bending, use jigs to produce uniform curvature for each repetitive configuration required. Maintain cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of components.
- F. Close exposed ends of railing and guard members with prefabricated end fittings.
- G. Provide wall returns at ends of wall-mounted handrails unless otherwise indicated.
1. Close ends of returns unless clearance between end of rail and wall is 1/4 inch (6 mm) or less.
- H. Connect posts to stair framing by direct welding unless otherwise indicated.
- I. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, end closures, flanges, miscellaneous fittings, and anchors for interconnecting components and for attaching to other work.
1. Furnish inserts and other anchorage devices for connecting to concrete or masonry work.
 2. For galvanized railings and guards, provide galvanized fittings, brackets, fasteners, sleeves, and other ferrous-metal components.
 3. For nongalvanized railings and guards, provide nongalvanized ferrous-metal fittings, brackets, fasteners, and sleeves, except galvanize anchors embedded in exterior masonry and concrete construction.
 4. Provide type of bracket **with flange tapped for concealed anchorage to threaded hanger bolt** and that provides 1-1/2-inch (38-mm) clearance from inside face of handrail to finished wall surface.

- J. Fillers: Provide fillers made from steel plate, or other suitably crush-resistant material, where needed to transfer wall bracket loads through wall finishes to structural supports.
 - 1. Size fillers to suit wall finish thicknesses and to produce adequate bearing area to prevent bracket rotation and overstressing of substrate.

2.9 FINISHES

- A. Finish metal stairs after assembly.
- B. Galvanizing: Hot-dip galvanize items as indicated to comply with ASTM A153/A153M for steel and iron hardware and with ASTM A123/A123M for other steel and iron products.
 - 1. Do not quench or apply post-galvanizing treatments that might interfere with paint adhesion.
 - 2. Fill vent and drain holes that are exposed in the finished Work, unless indicated to remain as weep holes, by plugging with zinc solder and filing off smooth.
- C. Preparation for Shop Priming: Prepare uncoated, ferrous-metal surfaces to comply with SSPC-SP 3, "Power Tool Cleaning."
- D. Apply shop primer to uncoated surfaces of metal stair components, except those with galvanized finishes and those to be embedded in concrete or masonry unless otherwise indicated. Comply with SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify elevations of floors, bearing surfaces and locations of bearing plates, and other embedments for compliance with requirements.
 - 1. For wall-mounted railings, verify locations of concealed reinforcement within gypsum board and plaster assemblies.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF METAL PAN STAIRS

- A. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing metal stairs to in-place construction.
 - 1. Include threaded fasteners for concrete and masonry inserts, through-bolts, lag bolts, and other connectors.

- B. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal stairs. Set units accurately in location, alignment, and elevation, measured from established lines and levels and free of rack.
- C. Install metal stairs by welding stair framing to steel structure or to weld plates cast into concrete unless otherwise indicated.
 - 1. Grouted Baseplates: Clean concrete- and masonry-bearing surfaces of bond-reducing materials, and roughen surfaces prior to setting plates.
 - a. Clean bottom surface of plates.
 - b. Set plates for structural members on wedges, shims, or setting nuts.
 - c. Tighten anchor bolts after supported members have been positioned and plumbed.
 - d. Do not remove wedges or shims but, if protruding, cut off flush with edge of plate before packing with grout.
 - e. Promptly pack grout solidly between bearing surfaces and plates so no voids remain.
 - 1) Neatly finish exposed surfaces; protect grout and allow to cure.
 - 2) Comply with manufacturer's written installation instructions for shrinkage-resistant grouts.
- D. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.
- E. Fit exposed connections accurately together to form hairline joints.
 - 1. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations.
 - 2. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.
 - 3. Comply with requirements for welding in "Fabrication, General" Article.
- F. Place and finish concrete fill for treads and platforms to comply with Section 033000 "Cast-in-Place Concrete."
 - 1. Install abrasive nosings with anchors fully embedded in concrete.
 - 2. Center nosings on tread width.
- G. Install precast concrete treads with adhesive supplied by manufacturer.
- H. Install precast terrazzo treads according to manufacturer's written instructions.

3.3 INSTALLATION OF RAILINGS AND GUARDS

- A. Adjust railing and guard systems before anchoring to ensure matching alignment at abutting joints with tight, hairline joints.

1. Space posts at spacing indicated or, if not indicated, as required by design loads.
2. Plumb posts in each direction, within a tolerance of 1/16 inch in 3 feet (2 mm in 1 m).
3. Align rails and guards so variations from level for horizontal members and variations from parallel with rake of stairs for sloping members do not exceed 1/4 inch in 12 feet (6 mm in 3.5 m).
4. Secure posts, rail ends, and guard ends to building construction as follows:
 - a. Anchor posts to steel by **bolting** to steel supporting members.
 - b. Anchor handrail and guard ends to concrete and masonry with steel round flanges welded to rail and guard ends and anchored with post-installed anchors and bolts.

B. Install railing gates level, plumb, and secure for full opening without interference.

1. Attach hardware using tamper-resistant or concealed means.
2. Adjust hardware for smooth operation.

C. Attach handrails to wall with wall brackets.

1. Locate brackets as indicated or, if not indicated, at spacing required to support structural loads.
2. Secure wall brackets to building construction as **required to comply with performance requirements. follows:**
 - a. For steel-framed partitions, use hanger or lag bolts set into **fire-retardant-treated** wood backing between studs. Coordinate with stud installation to locate backing members.
 - b. For steel-framed partitions, use self-tapping screws fastened to steel framing or to concealed steel reinforcements.
 - c. For steel-framed partitions, use toggle bolts installed through flanges of steel framing or through concealed steel reinforcements.

3.4 REPAIR

- A. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
 1. Apply by brush or spray to provide a minimum 2.0-mil (0.05-mm) dry film thickness.
- B. Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in **Section 099000 Painting**.
- C. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A780/A780M.

END OF SECTION 055113

Special Specification RMA7

Section 055213

Railing

SECTION 055213 - PIPE AND TUBE RAILINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

1. Steel railings.
2. Aluminum railings.
3. Stainless steel railings.

- B. Related Requirements:

1. Section 055113 "Metal Pan Stairs" for steel tube railings associated with metal pan stairs.
- 2.

1.3 COORDINATION

- A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.
- B. Coordinate installation of anchorages for railings. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

1.4 ACTION SUBMITTALS

- A. Product Data:

1. Manufacturer's product lines of mechanically connected railings.
2. Fasteners.
3. Post-installed anchors.
4. Handrail brackets.
5. Shop primer.
6. Intermediate coats and topcoats.

7. Nonshrink, nonmetallic grout.
8. Anchoring cement.
9. Metal finishes.
10. Paint products.

B. Sustainable Design Submittals:

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

D. Samples for Initial Selection: For products involving selection of color, texture, or design.

E. Samples for Verification: For each type of exposed finish required.

1. Sections of each distinctly different linear railing member, including handrails, top rails, posts, and balusters, including finish.
2. Fittings and brackets.
3. Assembled Sample of railing system, made from full-size components, including top rail, post, handrail, and infill. Sample need not be full height.

a. Show method of **connecting and finishing** members at intersections.

F. Delegated-Design Submittal: For railings, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For **delegated-design professional engineer**.

B. Welding certificates.

C. Mill Certificates: Signed by manufacturers of stainless steel products, certifying that products furnished comply with requirements.

D. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers, certifying that shop primers are compatible with topcoats.

E. Product Test Reports: For tests on railings performed by a qualified testing agency, in accordance with ASTM E894 and ASTM E935.

F. Research Reports: For post-installed anchors, from ICC-ES or other qualified testing agency acceptable to authorities having jurisdiction.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel in accordance with the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Protect mechanical finishes on exposed surfaces of railings from damage by applying a strippable, temporary protective covering before shipping.

1.8 FIELD CONDITIONS

- A. Field Measurements: Verify actual locations of walls and other construction contiguous with railings by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design railings, including attachment to building construction.
- B. Structural Performance: Railings, including attachment to building construction, shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
 - 1. Handrails and Top Rails of Guards:
 - a. Uniform load of 50 lbf/ ft. (0.73 kN/m) applied in any direction.
 - b. Concentrated load of 200 lbf (0.89 kN) applied in any direction.
 - c. Uniform and concentrated loads need not be assumed to act concurrently.
 - 2. Infill of Guards:
 - a. Concentrated load of 50 lbf (0.22 kN) applied horizontally on an area of 1 sq. ft. (0.093 sq. m).
 - b. Infill load and other loads need not be assumed to act concurrently.
- C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 - 1. Temperature Change: **120 deg F (67 deg C), ambient;**

2.2 METALS, GENERAL

- A. Metal Surfaces, General: Provide materials with smooth surfaces, without seam marks, roller marks, rolled trade names, stains, discolorations, or blemishes.
- B. Brackets, Flanges, and Anchors: Cast or formed metal of same type of material and finish as supported rails unless otherwise indicated.

1. Provide type of bracket with **flange tapped for concealed anchorage to threaded hanger bolt** and that provides 1-1/2-inch (38-mm) clearance from inside face of handrail to finished wall surface. Steel pipe railings are generally fabricated by local ironworks. If listing manufacturers from Paragraph Builder, consider adding names of local fabricators to list.
- C. Source Limitations: Obtain each type of railing from single source from single manufacturer.
- D. Tubing: **ASTM A500/A500M (cold formed)**.
- E. Pipe: ASTM A53/A53M, Type F or Type S, Grade A, Standard Weight (Schedule 40), unless another grade and weight are required by structural loads.
 1. Provide galvanized finish for exterior installations and where indicated.
- F. Plates, Shapes, and Bars: ASTM A36/A36M.
- G. Cast Iron Fittings: Either gray iron, ASTM A48/A48M, or malleable iron, ASTM A47/A47M, unless otherwise indicated.
 1. Galvanized-Steel Sheet, ASTM A653/A653M, G90 (Z275) coating, commercial steel Type B, **0.064 inch (1.63 mm), with 1/4-inch (6.4-mm) holes 3/8 inch (9.5 mm) o.c. in staggered rows.**

2.3 FASTENERS

- A. Fastener Materials:
 1. Ungalvanized-Steel Railing Components: Plated steel fasteners complying with ASTM F1941 (ASTM F1941M), Class Fe/Zn 5 for zinc coating.
 2. Hot-Dip Galvanized Railing Components: Type 304 stainless steel or hot-dip zinc-coated steel fasteners complying with ASTM A153/A153M or ASTM F2329/F2329M for zinc coating.
 3. Aluminum Railing Components: Type 304 stainless steel fasteners.
 4. Stainless Steel Railing Components: Type 304 stainless steel fasteners.
 5. Finish exposed fasteners to match appearance, including color and texture, of railings.
- B. Fasteners for Anchoring Railings to Other Construction: Select fasteners of type, grade, and class required to produce connections suitable for anchoring railings to other types of construction **and capable of withstanding design loads**.
- C. Fasteners for Interconnecting Railing Components:
 1. Provide concealed fasteners for interconnecting railing components and for attaching them to other work, unless otherwise indicated.

2. Provide concealed fasteners for interconnecting railing components and for attaching them to other work, unless exposed fasteners are unavoidable or are the standard fastening method for railings indicated.
 3. Provide **Phillips** flat-head machine screws for exposed fasteners unless otherwise indicated.
- D. Post-Installed Anchors: Fastener systems with working capacity greater than or equal to the design load, according to an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC193 or **ICC-ES AC308**.
1. Material for Interior Locations: Carbon-steel components zinc-plated to comply with ASTM B633 or ASTM F1941/F1941M, Class Fe/Zn 5, unless otherwise indicated.
 2. Material for Exterior Locations and Where Stainless Steel Is Indicated: Alloy Group 1 (A1) stainless steel bolts, ASTM F593, and nuts, ASTM F594.

2.4 MISCELLANEOUS MATERIALS

- A. Handrail Brackets: Cast nickel-silver, center of handrail **2-1/2 inches (63.5 mm)**. Welding Rods and Bare Electrodes: Select in accordance with AWS specifications for metal alloy welded.
- B. Etching Cleaner for Galvanized Metal: Complying with MPI#25.
- C. Galvanizing Repair Paint: High-zinc-dust-content paint, complying with SSPC-Paint 20 and compatible with paints specified to be used over it.
- D. Shop Primers: Provide primers that comply with **Section 099000 Painting**.
- E. Universal Shop Primer" Paragraph below specifies a typical primer for painted finishes that provides minimum protection to steel.
- F. Universal Shop Primer: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with MPI#79 and compatible with topcoat.
1. Use primer containing pigments that make it easily distinguishable from zinc-rich primer.
- G. Epoxy Zinc-Rich Primer: Complying with MPI#20 and compatible with topcoat.
- H. Shop Primer for Galvanized Steel: Primer formulated for exterior use over zinc-coated metal and compatible with finish paint systems indicated.
- I. Intermediate Coats and Topcoats: Provide products that comply with **Section 099000 Painting**. Epoxy Intermediate Coat: Complying with MPI #77 and compatible with primer and topcoat.
- J. Polyurethane Topcoat: Complying with MPI #72 and compatible with undercoat.

- K. Bituminous Paint: Cold-applied asphalt emulsion, complying with ASTM D1187/D1187M.
- L. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout, complying with ASTM C1107/C1107M. Provide grout specifically recommended by manufacturer for interior and exterior applications.
- M. Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with water at Project site to create pourable anchoring, patching, and grouting compound.
 - 1. Water-Resistant Product: **where indicated on Drawings**, provide formulation that is resistant to erosion from water exposure without needing protection by a sealer or waterproof coating and that is recommended by manufacturer for exterior use.

2.5 FABRICATION

- A. General: Fabricate railings to comply with requirements indicated for design, dimensions, member sizes and spacing, details, finish, and anchorage, **but not less than that required to support structural loads**.
- B. Shop assemble railings to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations.
 - 1. Clearly mark units for reassembly and coordinated installation.
 - 2. Use connections that maintain structural value of joined pieces.
- C. Cut, drill, and punch metals cleanly and accurately.
 - 1. Remove burrs and ease edges to a radius of approximately 1/32 inch (1 mm) unless otherwise indicated.
 - 2. Remove sharp or rough areas on exposed surfaces.
- D. Form work true to line and level with accurate angles and surfaces.
- E. Fabricate connections that are exposed to weather in a manner that excludes water.
 - 1. Provide weep holes where water may accumulate.
 - 2. Locate weep holes in inconspicuous locations.
- F. Cut, reinforce, drill, and tap as indicated to receive finish hardware, screws, and similar items.
- G. Connections: Fabricate railings with **welded** connections unless otherwise indicated.
- H. Welded Connections: Cope components at connections to provide close fit, or use fittings designed for this purpose. Weld all around at connections, including at fittings.

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 2. Obtain fusion without undercut or overlap.
 3. Remove flux immediately.
 4. At exposed connections, finish exposed welds to comply with NOMMA's "Voluntary Joint Finish Standards" for **Finish #1 welds; ornamental quality with no evidence of a welded joint.**
- I. Welded Connections for Aluminum Pipe: Fabricate railings to interconnect members with concealed internal welds that eliminate surface grinding, using manufacturer's standard system of sleeve and socket fittings.
- J. Nonwelded Connections: Connect members with concealed mechanical fasteners and fittings. Fabricate members and fittings to produce flush, smooth, rigid, hairline joints.
1. Fabricate splice joints for field connection, using an epoxy structural adhesive, if this is manufacturer's standard splicing method.
- K. Form changes in direction as follows:
1. As detailed.
 2. **By radius bends of radius indicated or by inserting prefabricated elbow fittings of radius indicated.**
- L. Bend members in jigs to produce uniform curvature for each configuration required. Maintain cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of components.
- M. Close exposed ends of hollow railing members with prefabricated cap and end fittings of same metal and finish as railings.
- N. Provide wall returns at ends of wall-mounted handrails unless otherwise indicated. Close ends of returns unless clearance between end of rail and wall is 1/4 inch (6 mm) or less.
- O. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, flanges, miscellaneous fittings, and anchors to interconnect railing members to other work unless otherwise indicated.
1. At brackets and fittings fastened to plaster or gypsum board partitions, provide crush-resistant fillers or other means to transfer loads through wall finishes to structural supports and prevent bracket or fitting rotation and crushing of substrate.
- P. Provide inserts and other anchorage devices for connecting railings to concrete or masonry work.
1. Fabricate anchorage devices capable of withstanding loads imposed by railings.
 2. Coordinate anchorage devices with supporting structure.

- Q. For railing posts set in concrete, provide stainless steel sleeves not less than 6 inches (150 mm) long with inside dimensions not less than 1/2 inch (13 mm) greater than outside dimensions of post, with metal plate forming bottom closure.
- R. For removable railing posts, fabricate slip-fit sockets from stainless steel tube or pipe whose ID is sized for a close fit with posts; limit movement of post without lateral load, measured at top, to not more than one-fortieth of post height.
 - 1. Provide socket covers designed and fabricated to resist being dislodged.
 - 2. Provide chain with eye, snap hook, and staple across gaps formed by removable railing sections at locations indicated. Fabricate from same metal as railings.
- S. Toe Boards: Where indicated, provide toe boards at railings around openings and at edge of open-sided floors and platforms. Fabricate to dimensions and details indicated.

2.6 STEEL AND IRON FINISHES

- A. Galvanized Railings:
 - 1. Hot-dip galvanize steel railings, including hardware, after fabrication.
 - 2. Comply with ASTM A123/A123M for hot-dip galvanized railings.
 - 3. Comply with ASTM A153/A153M for hot-dip galvanized hardware.
 - 4. Do not quench or apply post-galvanizing treatments that might interfere with paint adhesion.
 - 5. Fill vent and drain holes that are exposed in the finished Work, unless indicated to remain as weep holes, by plugging with zinc solder and filing off smooth.
- B. For galvanized railings, provide hot-dip galvanized fittings, brackets, fasteners, sleeves, and other ferrous components.
- C. Preparing Galvanized Railings for Shop Priming: After galvanizing, thoroughly clean railings of grease, dirt, oil, flux, and other foreign matter, and treat with etching cleaner and as follows.
 - 1. Comply with SSPC-SP 16.
- D. For nongalvanized-steel railings, provide nongalvanized ferrous-metal fittings, brackets, fasteners, and sleeves; however, hot-dip galvanize anchors to be embedded in exterior concrete or masonry.
- E. Preparation for Shop Priming: Prepare uncoated ferrous-metal surfaces to comply with SSPC-SP 6/NACE No. 3.
 - 1. Railings Indicated To Receive Zinc-Rich Primer: SSPC-SP 6/NACE No. 3.
 - 2. Railings Indicated To Receive Primers Specified in Section 099600 "High-Performance Coatings": SSPC-SP 6/NACE No. 3.
 - 3. Other Railings: SSPC-SP 3.

- F. Primer Application: Apply shop primer to prepared surfaces of railings unless otherwise indicated. Comply with requirements in SSPC-PA 1 for shop painting. Primer need not be applied to surfaces to be embedded in concrete or masonry.

1. Shop prime uncoated railings with **universal shop primer** unless "Single-Coat Superior Performance FEVE Organic Finish" Paragraph below is unsuitable for seacoast and severe environments.

2.7 EXAMINATION

- A. Examine plaster and gypsum board assemblies, where reinforced to receive anchors, to verify that locations of concealed reinforcements are clearly marked for Installer. Locate reinforcements and mark locations if not already done.

2.8 INSTALLATION, GENERAL

- A. Perform cutting, drilling, and fitting required for installing railings.
1. Fit exposed connections together to form tight, hairline joints.
 2. Install railings level, plumb, square, true to line; without distortion, warp, or rack.
 3. Set railings accurately in location, alignment, and elevation; measured from established lines and levels.
 4. Do not weld, cut, or abrade surfaces of railing components that are coated or finished after fabrication and that are intended for field connection by mechanical or other means without further cutting or fitting.
 5. Set posts plumb within a tolerance of 1/16 inch in 3 feet (2 mm in 1 m).
 6. Align rails so variations from level for horizontal members and variations from parallel with rake of steps and ramps for sloping members do not exceed 1/4 inch in 12 feet (6 mm in 3.5 m).
- B. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.
1. Coat concealed surfaces of aluminum that will be in contact with grout, concrete, masonry, wood, or dissimilar metals, with a heavy coat of bituminous paint.
- C. Adjust railings before anchoring to ensure matching alignment at abutting joints.
- D. Fastening to In-Place Construction: Use anchorage devices and fasteners where necessary for securing railings and for properly transferring loads to in-place construction.

2.9 RAILING CONNECTIONS

- A. Non-welded Connections: Use mechanical or adhesive joints for permanently connecting railing components. Use wood blocks and padding to prevent damage to

railing members and fittings. Seal recessed holes of exposed locking screws, using plastic cement filler colored to match finish of railings.

- B. Welded Connections: Use fully welded joints for permanently connecting railing components. Comply with requirements for welded connections in "Fabrication" Article, whether welding is performed in the shop or in the field.
- C. Expansion Joints: Install expansion joints at locations indicated but not farther apart than required to accommodate thermal movement. Provide slip-joint internal sleeve, extending 2 inches (50 mm) beyond joint on either side; fasten internal sleeve securely to one side; and locate joint within 6 inches (150 mm) of post.

2.10 ANCHORING POSTS

- A. Use stainless steel pipe sleeves preset and anchored into concrete for installing posts. After posts are inserted into sleeves, fill annular space between post and sleeve with **nonshrink, nonmetallic grout or anchoring cement**, mixed and placed to comply with anchoring material manufacturer's written instructions.
- B. Form or core-drill holes not less than 5 inches (125 mm) deep and 3/4 inch (20 mm) larger than OD of post for installing posts in concrete. Clean holes of loose material, insert posts, and fill annular space between post and concrete with **nonshrink, nonmetallic grout or anchoring cement**, mixed and placed to comply with anchoring material manufacturer's written instructions.
- C. Cover anchorage joint with flange of same metal as post, **welded to post after placing anchoring material**.
- D. Leave anchorage joint exposed with **anchoring material flush with adjacent surface**.
- E. Anchor posts to metal surfaces with flanges, angle type, or floor type, as required by conditions, connected to posts and to metal supporting members as follows:
 - 1. For steel railings, weld flanges to post and bolt to metal supporting surfaces.
 - 2. For aluminum railings, attach posts as indicated, using fittings designed and engineered for this purpose.
 - 3. For stainless steel railings, weld flanges to post and bolt to supporting surfaces.
- F. Install removable railing sections, where indicated, in slip-fit stainless steel sockets cast in concrete.

2.11 ATTACHING RAILINGS

- A. Anchor railing ends to metal surfaces with flanges bolted to metal surfaces and **welded to railing ends**.

- B. Attach handrails to walls with wall brackets, **except where end flanges are used**. Provide brackets with **1-1/2-inch (38-mm)** clearance from inside face of handrail and finished wall surface.
 - 1. Use type of bracket with flange tapped for concealed anchorage to threaded hanger bolt.
 - 2. Locate brackets as indicated or, if not indicated, at spacing required to support structural loads.
- C. Secure wall brackets and railing end flanges to building construction as follows:
 - 1. For concrete and solid masonry anchorage, use drilled-in expansion shields and hanger or lag bolts.
 - 2. For hollow masonry anchorage, use toggle bolts.
 - 3. For wood stud partitions, use hanger or lag bolts set into studs or wood backing between studs. Coordinate with carpentry work to locate backing members.
 - 4. For steel-framed partitions, use hanger or lag bolts set into **fire-retardant-treated** wood backing between studs. Coordinate with stud installation to locate backing members.
 - 5. For steel-framed partitions, fasten brackets directly to steel framing or concealed steel reinforcements, using self-tapping screws of size and type required to support structural loads.
 - 6. For steel-framed partitions, use toggle bolts installed through flanges of steel framing or through concealed steel reinforcements.

2.12 REPAIR

- A. Touchup Painting:
 - 1. Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with the same material used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
 - a. Apply by brush or spray to provide a minimum 2.0-mil (0.05-mm) dry film thickness.
- B. Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in **Section 099000 Painting**.

2.13 CLEANING

- A. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas, and repair galvanizing to comply with ASTM A780/A780M.

2.14 PROTECTION

- A. Protect finishes of railings from damage during construction period with temporary protective coverings approved by railing manufacturer. Remove protective coverings at time of Substantial Completion.
- B. Restore finishes damaged during installation and construction period, so no evidence remains of correction work. Return items that cannot be refinished in the field to the shop; make required alterations and refinish entire unit, or provide new units.

END OF SECTION 055213

Special Specification RMA8

Section 133419

Aircraft Hangar

SECTION 13 34 19 - METAL BUILDING SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Structural-steel framing.
 - 2. Metal roof panels.
 - 3. Metal wall panels.
 - 4. Metal soffit panels.
 - 5. Thermal insulation.
 - 6. Accessories.
- B. Related Requirements:
 - 1. Section 083323 "Overhead Coiling Doors" for coiling vehicular doors in metal building systems.

1.3 DEFINITIONS

- A. Terminology Standard: See MBMA's "Metal Building Systems Manual" for definitions of terms for metal building system construction not otherwise defined in this Section or in standards referenced by this Section.

1.4 COORDINATION

- A. Coordinate sizes and locations of concrete foundations and casting of anchor-rod inserts into foundation walls and footings. Anchor rod installation, concrete, reinforcement, and formwork requirements are specified in Section 033000 "Cast-in-Place Concrete."
- B. Coordinate metal panel assemblies with rain drainage work, flashing, trim, and construction of supports and other adjoining work to provide a leakproof, secure, and noncorrosive installation.

1.5 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 - 1. Review methods and procedures related to metal building systems including, but not limited to, the following:

- a. Condition of foundations and other preparatory work performed by other trades.
 - b. Structural load limitations.
 - c. Construction schedule. Verify availability of materials and erector's personnel, equipment, and facilities needed to make progress and avoid delays.
 - d. Required tests, inspections, and certifications.
 - e. Unfavorable weather and forecasted weather conditions and impact on construction schedule.
2. Review methods and procedures related to metal roof panel assemblies including, but not limited to, the following:
 - a. Compliance with requirements for purlin and rafter conditions, including flatness and attachment to structural members.
 - b. Structural limitations of purlins and rafters during and after roofing.
 - c. Flashings, special roof details, roof drainage, roof penetrations, equipment curbs, and condition of other construction that will affect metal roof panels.
 - d. Temporary protection requirements for metal roof panel assembly during and after installation.
 - e. Roof observation and repair after metal roof panel installation.
3. Review methods and procedures related to metal wall panel assemblies including, but not limited to, the following:
 - a. Compliance with requirements for support conditions, including alignment between and attachment to structural members.
 - b. Structural limitations of girts and columns during and after wall panel installation.
 - c. Flashings, special siding details, wall penetrations, openings, and condition of other construction that will affect metal wall panels.
 - d. Temporary protection requirements for metal wall panel assembly during and after installation.
 - e. Wall observation and repair after metal wall panel installation.

1.6 ACTION SUBMITTALS

- A. Product Data: For each type of metal building system component.
 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
 - a. Metal roof panels.
 - b. Metal wall panels.
 - c. Metal soffit panels.
 - d. Thermal insulation and vapor-retarder facings.
 - e. Roof ventilators.
 - f. Louvers.
- B. Shop Drawings: Indicate components by others. Include full building plan, elevations, sections, details and the following:
 1. Anchor-Rod Plans: Submit anchor-rod plans and templates before foundation work begins. Include location, diameter, and minimum required projection of anchor rods required to attach metal building to foundation. Indicate column reactions at each location.

2. Structural-Framing Drawings: Show complete fabrication of primary and secondary framing; include provisions for openings. Indicate welds and bolted connections, distinguishing between shop and field applications. Include transverse cross-sections.
 - a. Show provisions for attaching to existing building.
 3. Metal Roof and Wall Panel Layout Drawings: Show layouts of panels including methods of support. Include details of edge conditions, joints, panel profiles, corners, anchorages, clip spacing, trim, flashings, closures, and special details. Distinguish between factory- and field-assembled work; show locations of exposed fasteners.
 - a. Show wall-mounted items including personnel doors, vehicular doors, windows, louvers, and lighting fixtures.
 4. Accessory Drawings: Include details of the following items, at a scale of not less than 1-1/2 inches per 12 inches:
 - a. Flashing and trim.
 - b. Gutters.
 - c. Downspouts.
- C. Samples for Verification: For the following products: Match Existing.
1. Panels: Nominal 12 inches long by actual panel width. Include fasteners, closures, and other exposed panel accessories.
 2. Flashing and Trim: Nominal 12 inches long. Include fasteners and other exposed accessories.
- D. Delegated-Design Submittal: For metal building systems.
1. Include analysis data indicating compliance with performance requirements and design data signed and sealed by the qualified professional engineer responsible for their preparation.

1.7 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For manufacturer.
- B. Letter of Design Certification: Signed and sealed by a qualified professional engineer. Include the following:
1. Name and location of Project.
 2. Order number.
 3. Name of manufacturer.
 4. Name of Contractor.
 5. Building dimensions including width, length, height, and roof slope.
 6. Indicate compliance with AISC standards for hot-rolled steel and AISI standards for cold-rolled steel, including edition dates of each standard.
 7. Governing building code and year of edition.
 8. Design Loads: Include dead load, roof live load, collateral loads, roof snow load, deflection, wind loads/speeds and exposure, seismic design category or effective peak velocity-related acceleration/peak acceleration, and auxiliary loads (cranes).
 9. Load Combinations: Indicate that loads were applied acting simultaneously with concentrated loads, according to governing building code.

10. Building-Use Category: Indicate category of building use and its effect on load importance factors.

C. Material Test Reports: For each of the following products:

1. Structural steel including chemical and physical properties.
2. Bolts, nuts, and washers including mechanical properties and chemical analysis.
3. Tension-control, high-strength, bolt-nut-washer assemblies.
4. Shop primers.
5. Nonshrink grout.

D. Source quality-control reports.

E. Field quality-control reports.

F. Surveys: Show final elevations and locations of major members. Indicate discrepancies between actual installation and the Contract Documents. Have surveyor who performed surveys certify their accuracy.

G. Sample Warranties: For special warranties.

1.8 CLOSEOUT SUBMITTALS

A. Maintenance Data: For metal panel finishes to include in maintenance manuals.

1.9 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer.

1. Accreditation: Manufacturer's facility accredited according to the International Accreditation Service's AC472, "Accreditation Criteria for Inspection Programs for Manufacturers of Metal Building Systems."
2. Engineering Responsibility: Preparation of comprehensive engineering analysis and Shop Drawings by a professional engineer who is legally qualified to practice in jurisdiction where Project is located.

B. Erector Qualifications: An experienced erector who specializes in erecting and installing work similar in material, design, and extent to that indicated for this Project and who is acceptable to manufacturer.

C. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.3, "Structural Welding Code - Sheet Steel."

1.10 DELIVERY, STORAGE, AND HANDLING

A. Deliver components, sheets, panels, and other manufactured items so as not to be damaged or deformed. Package metal panels for protection during transportation and handling.

- B. Unload, store, and erect metal panels in a manner to prevent bending, warping, twisting, and surface damage.
- C. Stack metal panels horizontally on platforms or pallets, covered with suitable weathertight and ventilated covering. Store metal panels to ensure dryness, with positive slope for drainage of water. Do not store metal panels in contact with other materials that might cause staining, denting, or other surface damage.

1.11 FIELD CONDITIONS

- A. Weather Limitations: Proceed with panel installation only when weather conditions permit metal panels to be installed according to manufacturers' written instructions and warranty requirements.

1.12 WARRANTY

- A. Special Warranty on Metal Panel Finishes: Manufacturer agrees to repair finish or replace metal panels that show evidence of deterioration of factory-applied finishes within specified warranty period.
 - 1. Exposed Panel Finish: Deterioration includes, but is not limited to, the following:
 - a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.
 - b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
 - c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
 - 2. Finish Warranty Period: 20 years from date of Substantial Completion.
- B. Special Weathertightness Warranty for Standing-Seam Metal Roof Panels: Manufacturer agrees to repair or replace standing-seam metal roof panel assemblies that leak or otherwise fail to remain weathertight within specified warranty period.
 - 1. Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Alliance Steel, Inc.
 - 2. Butler Manufacturing Company; a division of BlueScope Buildings North America, Inc.
 - 3. Nucor Building Systems.
- B. Source Limitations: Obtain metal building system components, including primary and secondary framing and metal panel assemblies, from single source from single manufacturer.

2.2 SYSTEM DESCRIPTION

- A. Provide a complete, integrated set of mutually dependent components and assemblies that form a metal building system capable of withstanding structural and other loads, thermally induced movement, and exposure to weather without failure or infiltration of water into building interior.
- B. Primary-Frame Type:
 - 1. Rigid Modular: Solid-member, structural-framing system with interior columns.
- C. End-Wall Framing: Manufacturer's standard, for buildings not required to be expandable, consisting of primary frame, capable of supporting one-half of a bay design load, and end-wall columns.
- D. Secondary-Frame Type: Manufacturer's standard purlins and joists and exterior-framed (bypass) girts.
- E. Eave Height: As indicated on drawings.
- F. Bay Spacing: As indicated on drawings.
- G. Roof Slope: As indicated on drawings.
- H. Roof System: Manufacturer's standard structural standing-seam, trapezoidal-rib, metal roof panels.
- I. Exterior Wall System: Manufacturer's standard exposed-fastener, metal wall panels, match existing.

2.3 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design metal building system.
- B. Structural Performance: Metal building systems shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated according to procedures in MBMA's "Metal Building Systems Manual."
 - 1. Design Loads: As indicated on Drawings.
 - 2. Deflection and Drift Limits: Design metal building system assemblies to withstand serviceability design loads without exceeding deflections and drift limits recommended in AISC Steel Design Guide No. 3 "Serviceability Design Considerations for Steel Buildings."
 - 3. Deflection and Drift Limits: No greater than the following:
 - a. Purlins and Rafters: Vertical deflection of 1/240 of the span.
 - b. Girts: Horizontal deflection of 1/180 of the span.
 - c. Metal Roof Panels: Vertical deflection of 1/240 of the span.
 - d. Metal Wall Panels: Horizontal deflection of 1/240 Insert limit of the span.
 - e. Design secondary-framing system to accommodate deflection of primary framing and construction tolerances, and to maintain clearances at openings.

- f. Lateral Drift: Maximum of 1/400 of the building height.
- C. Seismic Performance: Metal building system shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
- D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 - 1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.
- E. Structural Performance for Metal Roof and Wall Panels: Provide metal panel systems capable of withstanding the effects of the following loads, based on testing according to ASTM E 1592:
 - 1. Wind Loads: As indicated on Drawings.
- F. Air Infiltration for Metal Roof Panels: Air leakage of not more than 0.06 cfm/sq. ft. when tested according to ASTM E 1680 or ASTM E 283 at the following test-pressure difference:
 - 1. Test-Pressure Difference: 6.24 lbf/sq. ft..
- G. Air Infiltration for Metal Wall Panels: Air leakage of not more than 0.06 cfm/sq. ft. when tested according to ASTM E 283 at the following test-pressure difference:
 - 1. Test-Pressure Difference: 6.24 lbf/sq. ft..
- H. Water Penetration for Metal Roof Panels: No water penetration when tested according to ASTM E 1646 or ASTM E 331 at the following test-pressure difference:
 - 1. Test-Pressure Difference: 6.24 lbf/sq. ft..
- I. Water Penetration for Metal Wall Panels: No water penetration when tested according to ASTM E 331 at the following test-pressure difference:
 - 1. Test-Pressure Difference: 6.24 lbf/sq. ft..
- J. FM Global Listing: Provide metal roof panels and component materials that comply with requirements in FM Global 4471 as part of a panel roofing system and that are listed in FM Global's "Approval Guide" for Class 1 or noncombustible construction, as applicable. Identify materials with FM Global markings.
 - 1. Fire/Windstorm Classification: As indicated on drawings.
 - 2. Hail Resistance: SH.
- K. Thermal Performance for Opaque Elements: Provide the following maximum U-factors and minimum R-values when tested according to ASTM C 1363 or ASTM C 518:
 - 1. Roof:
 - a. U-Factor: As indicated on drawings.
 - b. R-Value: As indicated on drawings.
 - 2. Walls:
 - a. U-Factor: As indicated on drawings.
 - b. R-Value: As indicated on drawings.

2.4 STRUCTURAL-STEEL FRAMING

- A. Structural Steel: Comply with AISC 360, "Specification for Structural Steel Buildings."
- B. Bolted Connections: Comply with RCSC's "Specification for Structural Joints Using High-Strength Bolts."
- C. Cold-Formed Steel: Comply with AISI's "North American Specification for the Design of Cold-Formed Steel Structural Members" for design requirements and allowable stresses.
- D. Primary Framing: Manufacturer's standard primary-framing system, designed to withstand required loads and specified requirements. Primary framing includes transverse and lean-to frames; rafters, rake, and canopy beams; sidewall, intermediate, end-wall, and corner columns; and wind bracing.
 - 1. General: Provide frames with attachment plates, bearing plates, and splice members. Factory drill for field-bolted assembly. Provide frame span and spacing indicated.
 - 2. Rigid Modular Frames: I-shaped frame sections fabricated from shop-welded, built-up steel plates or structural-steel shapes. Provide interior columns fabricated from round steel pipes or tubes, or shop-welded, built-up steel plates.
 - 3. Long-Bay Frames: I-shaped frame sections fabricated from shop-welded, built-up steel plates or structural-steel shapes. Provide interior columns fabricated from round steel pipes or tubes, or shop-welded, built-up steel plates.
- E. End-Wall Framing: Manufacturer's standard primary end-wall framing fabricated for field-bolted assembly to comply with the following:
 - 1. End-Wall and Corner Columns: I-shaped sections fabricated from structural-steel shapes; shop-welded, built-up steel plates; or C-shaped, cold-formed, structural-steel sheet.
 - 2. End-Wall Rafters: C-shaped, cold-formed, structural-steel sheet; or I-shaped sections fabricated from shop-welded, built-up steel plates or structural-steel shapes.
- F. Secondary Framing: Manufacturer's standard secondary framing, including purlins, girts, eave struts, flange bracing, base members, gable angles, clips, headers, jambs, and other miscellaneous structural members. Unless otherwise indicated, fabricate framing from either cold-formed, structural-steel sheet or roll-formed, metallic-coated steel sheet, prepainted with coil coating, to comply with the following:
 - 1. Purlins: C- or Z-shaped sections; fabricated from built-up steel plates, steel sheet, or structural-steel shapes; minimum 2-1/2-inch- wide flanges.
 - a. Depth: To match existing.
 - 2. Girts: C- or Z-shaped sections; fabricated from built-up steel plates, steel sheet, or structural-steel shapes. Form ends of Z-sections with stiffening lips angled 40 to 50 degrees from flange, with minimum 2-1/2-inch- wide flanges.
 - a. Depth: To match existing.
 - 3. Eave Struts: Unequal-flange, C-shaped sections; fabricated from built-up steel plates, steel sheet, or structural-steel shapes; to provide adequate backup for metal panels.

4. Flange Bracing: Minimum 2-by-2-by-1/8-inch structural-steel angles or 1-inch-diameter, cold-formed structural tubing to stiffen primary-frame flanges.
 5. Sag Bracing: Minimum 1-by-1-by-1/8-inch structural-steel angles.
 6. Base or Sill Angles: Manufacturer's standard base angle, minimum 3-by-2-inch, fabricated from zinc-coated (galvanized) steel sheet.
 7. Purlin and Girt Clips: Manufacturer's standard clips fabricated from steel sheet. Provide galvanized clips where clips are connected to galvanized framing members.
 8. Framing for Openings: Channel shapes; fabricated from cold-formed, structural-steel sheet or structural-steel shapes. Frame head and jamb of door openings and head, jamb, and sill of other openings.
 9. Miscellaneous Structural Members: Manufacturer's standard sections fabricated from cold-formed, structural-steel sheet; built-up steel plates; or zinc-coated (galvanized) steel sheet; designed to withstand required loads.
- G. Bracing: Provide adjustable wind bracing using any method as follows:
1. Rods: ASTM A 36/A 36M; ASTM A 572/A 572M, Grade 50; or ASTM A 529/A 529M, Grade 50; minimum 1/2-inch- diameter steel; threaded full length or threaded a minimum of 6 inches at each end.
 2. Cable: ASTM A 475, minimum 1/4-inch- diameter, extra-high-strength grade, Class B, zinc-coated, seven-strand steel; with threaded end anchors.
 3. Angles: Fabricated from structural-steel shapes to match primary framing, of size required to withstand design loads.
 4. Rigid Portal Frames: Fabricated from shop-welded, built-up steel plates or structural-steel shapes to match primary framing; of size required to withstand design loads.
 5. Fixed-Base Columns: Fabricated from shop-welded, built-up steel plates or structural-steel shapes to match primary framing; of size required to withstand design loads.
 6. Diaphragm Action of Metal Panels: Design metal building to resist wind forces through diaphragm action of metal panels.
- H. Materials:
1. W-Shapes: ASTM A 992/A 992M; ASTM A 572/A 572M, Grade 50 or 55; or ASTM A 529/A 529M, Grade 50 or 55.
 2. Channels, Angles, M-Shapes, and S-Shapes: ASTM A 36/A 36M; ASTM A 572/A 572M, Grade 50 or 55; or ASTM A 529/A 529M, Grade 50 or 55.
 3. Plate and Bar: ASTM A 36/A 36M; ASTM A 572/A 572M, Grade 50 or 55; or ASTM A 529/A 529M, Grade 50 or 55.
 4. Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade B.
 5. Cold-Formed Hollow Structural Sections: ASTM A 500, Grade B or C, structural tubing.
 6. Structural-Steel Sheet: Hot-rolled, ASTM A 1011/A 1011M, Structural Steel (SS), Grades 30 through 55, or High-Strength Low-Alloy Steel (HSLAS) or High-Strength Low-Alloy Steel with Improved Formability (HSLAS-F), Grades 45 through 70; or cold-rolled, ASTM A 1008/A 1008M, Structural Steel (SS), Grades 25 through 80, or HSLAS, Grades 45 through 70.
 7. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, SS, Grades 33 through 80, or HSLAS or HSLAS-F, Grades 50 through 80; with G60 coating designation; mill phosphatized.

8. Metallic-Coated Steel Sheet Prepainted with Coil Coating: Steel sheet, metallic coated by the hot-dip process and prepainted by the coil-coating process to comply with ASTM A 755/A 755M.
 - a. Zinc-Coated (Galvanized) Steel Sheet: ASTM A 653/A 653M, SS, Grades 33 through 80, or HSLAS or HSLAS-F, Grades 50 through 80; with G90 coating designation.
 - b. Aluminum-Zinc Alloy-Coated Steel Sheet: ASTM A 792/A 792M, SS, Grade 50 or 80; with Class AZ50 coating.
 9. Non-High-Strength Bolts, Nuts, and Washers: ASTM A 307, Grade A, carbon-steel, hex-head bolts; ASTM A 563 carbon-steel hex nuts; and ASTM F 844 plain (flat) steel washers.
 - a. Finish: Hot-dip zinc coating, ASTM F 2329, Class C.
 10. Structural Bolts, Nuts, and Washers: ASTM A 325, Type 1, heavy-hex steel structural bolts; ASTM A 563 heavy-hex carbon-steel nuts; and ASTM F 436 hardened carbon-steel washers.
 - a. Finish: Hot-dip zinc coating, ASTM F 2329, Class C.
 11. Tension-Control, High-Strength Bolt-Nut-Washer Assemblies: ASTM F 1852, Type 1, heavy-hex-head steel structural bolts with spline ends.
 - a. Finish: Mechanically deposited zinc coating, ASTM B 695, Class 50.
 12. Unheaded Anchor Rods: ASTM F 1554, Grade 36.
 - a. Configuration: Straight.
 - b. Nuts: ASTM A 563 heavy-hex carbon steel.
 - c. Plate Washers: ASTM A 36/A 36M carbon steel.
 - d. Washers: ASTM F 436 hardened carbon steel.
 - e. Finish: Hot-dip zinc coating, ASTM F 2329, Class C.
 13. Headed Anchor Rods: ASTM F 1554, Grade 36.
 - a. Configuration: Straight.
 - b. Nuts: ASTM A 563 heavy-hex carbon steel.
 - c. Plate Washers: ASTM A 36/A 36M carbon steel.
 - d. Washers: ASTM F 436 hardened carbon steel.
 - e. Finish: Hot-dip zinc coating, ASTM F 2329, Class C.
 14. Threaded Rods: ASTM A 193/A 193M.
 - a. Nuts: ASTM A 563 heavy-hex carbon steel.
 - b. Washers: ASTM F 436 hardened carbon steel.
 - c. Finish: Hot-dip zinc coating, ASTM F 2329, Class C.
- I. Finish: Factory primed. Apply specified primer immediately after cleaning and pretreating.
1. Clean and prepare in accordance with SSPC-SP2.
 2. Coat with manufacturer's standard primer. Apply primer to primary and secondary framing to a minimum dry film thickness of 1 mil.
 - a. Prime secondary framing formed from uncoated steel sheet to a minimum dry film thickness of 0.5 mil on each side.

2.5 METAL ROOF PANELS

- A. Structural Standing-Seam, Trapezoidal-Rib, Metal Roof Panels: Formed with raised trapezoidal ribs at panel edges and intermediate stiffening ribs symmetrically spaced between ribs; designed for sequential installation by mechanically attaching panels to

supports using concealed clips located under one side of panels and engaging opposite edge of adjacent panels, match existing profile.

1. Material: Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.030-inch nominal uncoated steel thickness. Prepainted by the coil-coating process to comply with ASTM A 755/A 755M.
 - a. Exterior Finish: Two-coat fluoropolymer.
 - b. Color: To match existing.
2. Clips: Two-piece floating to accommodate thermal movement.
3. Joint Type: Mechanically seamed.
4. Panel Coverage: 24 inches.
5. Panel Height: 3 inches.

B. Finishes:

1. Exposed Coil-Coated Finish:
 - a. Siliconized Polyester: Epoxy primer and silicone-modified, polyester-enamel topcoat; with a minimum dry film thickness of 0.2 mil for primer and 0.8 mil for topcoat.
2. Concealed Finish: Apply pretreatment and manufacturer's standard white or light-colored acrylic or polyester backer finish, consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil.

2.6 METAL WALL PANELS

A. Exposed-Fastener, Metal Wall Panels: Formed with raised ribs designed to be installed by lapping side edges of adjacent panels and mechanically attaching panels to supports using exposed fasteners in side laps.

1. Material: Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.018-inch nominal uncoated steel thickness. Prepainted by the coil-coating process to comply with ASTM A 755/A 755M.
 - a. Exterior Finish: Two-coat fluoropolymer.
 - b. Color: Match existing.
2. Rib Spacing: Match existing
3. Panel Coverage: Match existing.
4. Panel Height: Match existing.

B. Finishes:

1. Exposed Coil-Coated Finish:
 - a. Two-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
2. Concealed Finish: Apply pretreatment and manufacturer's standard white or light-colored acrylic or polyester backer finish, consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil.

2.7 METAL SOFFIT PANELS

A. General: Provide factory-formed metal soffit panels designed to be installed by lapping and interconnecting side edges of adjacent panels and mechanically attaching through

panel to supports using concealed fasteners in side laps. Include accessories required for weathertight installation.

- B. Metal Soffit Panels: Match profile and material of existing metal panels.
 - 1. Finish: Match existing.
- C. Concealed-Fastener, Flush-Profile, Metal Soffit Panels: Formed with vertical panel edges and flush surface; with flush joint between panels; with 1-inch- wide flange for attaching interior finish; designed to be installed by lapping and interconnecting side edges of adjacent panels and mechanically attaching through panel to supports using concealed fasteners in side laps.
 - 1. Material: Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.024-inch nominal uncoated steel thickness. Prepainted by the coil-coating process to comply with ASTM A 755/A 755M.
 - a. Exterior Finish: Fluoropolymer.
 - b. Color: Match existing.
 - 2. Panel Coverage: Match existing.
 - 3. Panel Height: Match existing.

2.8 THERMAL INSULATION

- A. Faced Metal Building Insulation: ASTM C 991, Type II, glass-fiber-blanket insulation; 0.5-lb/cu. ft. (8-kg/cu. m) density; 2-inch- (51-mm-) wide, continuous, vapor-tight edge tabs; with a flame-spread index of 25 or less.
- B. Retainer Strips: For securing insulation between supports, 0.025-inch (0.64-mm) nominal-thickness, formed, metallic-coated steel or PVC retainer clips colored to match insulation facing.
- C. Vapor-Retarder Facing: ASTM C 1136, with permeance not greater than 0.02 perm when tested according to ASTM E 96/E 96M, Desiccant Method.
 - 1. Composition: White metallized-polypropylene film facing, fiberglass scrim reinforcement, and kraft-paper backing.
- D. Vapor-Retarder Tape: Pressure-sensitive tape of type recommended by vapor-retarder manufacturer for sealing joints and penetrations in vapor retarder.

2.9 ACCESSORIES

- A. General: Provide accessories as standard with metal building system manufacturer and as specified. Fabricate and finish accessories at the factory to greatest extent possible, by manufacturer's standard procedures and processes. Comply with indicated profiles and with dimensional and structural requirements.
 - 1. Form exposed sheet metal accessories that are without excessive oil-canning, buckling, and tool marks and that are true to line and levels indicated, with exposed edges folded back to form hems.
- B. Roof Panel Accessories: Provide components required for a complete metal roof panel assembly including copings, fasciae, corner units, ridge closures, clips, sealants,

gaskets, fillers, closure strips, and similar items. Match material and finish of metal roof panels unless otherwise indicated.

1. Closures: Provide closures at eaves and ridges, fabricated of same material as metal roof panels.
2. Clips: Manufacturer's standard, formed from stainless-steel sheet, designed to withstand negative-load requirements.
3. Cleats: Manufacturer's standard, mechanically seamed cleats formed from stainless-steel sheet or nylon-coated aluminum sheet.
4. Backing Plates: Provide metal backing plates at panel end splices, fabricated from material recommended by manufacturer.
5. Closure Strips: Closed-cell, expanded, cellular, rubber or crosslinked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1-inch- thick, flexible closure strips; cut or premolded to match metal roof panel profile. Provide closure strips where indicated or necessary to ensure weathertight construction.
6. Thermal Spacer Blocks: Where metal panels attach directly to purlins, provide thermal spacer blocks of thickness required to provide 1-inch standoff; fabricated from extruded polystyrene.

C. Wall Panel Accessories: Provide components required for a complete metal wall panel assembly including copings, fasciae, mullions, sills, corner units, clips, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal wall panels unless otherwise indicated.

1. Closures: Provide closures at eaves and rakes, fabricated of same material as metal wall panels.
2. Backing Plates: Provide metal backing plates at panel end splices, fabricated from material recommended by manufacturer.
3. Closure Strips: Closed-cell, expanded, cellular, rubber or crosslinked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1-inch- thick, flexible closure strips; cut or premolded to match metal wall panel profile. Provide closure strips where indicated or necessary to ensure weathertight construction.

D. Flashing and Trim: Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.018-inch nominal uncoated steel thickness, prepainted with coil coating; finished to match adjacent metal panels.

1. Provide flashing and trim as required to seal against weather and to provide finished appearance. Locations include, but are not limited to, eaves, rakes, corners, bases, framed openings, ridges, fasciae, and fillers.
2. Opening Trim: Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.018-inch nominal uncoated steel thickness, prepainted with coil coating. Trim head and jamb of door openings, and head, jamb, and sill of other openings.

E. Gutters: Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.018-inch nominal uncoated steel thickness, prepainted with coil coating; finished to match roof fascia and rake trim. Match profile of gable trim, complete with end pieces, outlet tubes, and other special pieces as required. Fabricate in minimum 96-inch- long sections, sized according to SMACNA's "Architectural Sheet Metal Manual."

1. Gutter Supports: Fabricated from same material and finish as gutters.
2. Strainers: Bronze, copper, or aluminum wire ball type at outlets.

- F. Downspouts: Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.018-inch nominal uncoated steel thickness, prepainted with coil coating; finished to match metal wall panels. Fabricate in minimum 10-foot- long sections, complete with formed elbows and offsets.
 - 1. Mounting Straps: Fabricated from same material and finish as gutters.
- G. Louvers: Size and design indicated; self-framing and self-flashing. Fabricate welded frames from zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.048-inch nominal uncoated steel thickness; finished to match metal wall panels. Form blades from zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.036-inch nominal uncoated steel thickness; folded or beaded at edges, set at an angle that excludes driving rains, and secured to frames by riveting or welding. Fabricate louvers with equal blade spacing to produce uniform appearance.
 - 1. Blades: Fixed.
 - 2. Free Area: As indicated on drawings.
 - 3. Bird Screening: Galvanized steel, 1/2-inch- square mesh, 0.041-inch wire; with rewirable frames, removable and secured with clips; fabricated of same kind and form of metal and with same finish as louvers.
 - a. Mounting: Exterior face of louvers.
 - 4. Vertical Mullions: Provide mullions at spacings recommended by manufacturer, or 72 inches o.c., whichever is less.
- H. Roof Curbs: Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.048-inch nominal uncoated steel thickness prepainted with coil coating; finished to match metal roof panels; with welded top box and bottom skirt, and integral full-length cricket; capable of withstanding loads of size and height indicated.
 - 1. Curb Subframing: Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.060-inch nominal uncoated steel thickness, angle-, C-, or Z-shaped metallic-coated steel sheet.
 - 2. Insulation: 1-inch- thick, rigid type.
- I. Pipe Flashing: Premolded, EPDM pipe collar with flexible aluminum ring bonded to base.
- J. Materials:
 - 1. Fasteners: Self-tapping screws, bolts, nuts, self-locking rivets and bolts, end-welded studs, and other suitable fasteners designed to withstand design loads. Provide fasteners with heads matching color of materials being fastened by means of plastic caps or factory-applied coating.
 - a. Fasteners for Metal Roof Panels: Self-drilling or self-tapping, zinc-plated, hex-head carbon-steel screws, with a stainless-steel cap or zinc-aluminum-alloy head and EPDM sealing washer.
 - b. Fasteners for Metal Wall Panels: Self-drilling or self-tapping, zinc-plated, hex-head carbon-steel screws.
 - c. Fasteners for Flashing and Trim: Blind fasteners or self-drilling screws with hex washer head.
 - d. Blind Fasteners: High-strength aluminum or stainless-steel rivets.
 - 2. Corrosion-Resistant Coating: Cold-applied asphalt mastic, compounded for 15-mil dry film thickness per coat. Provide inert-type noncorrosive compound free of asbestos fibers, sulfur components, and other deleterious impurities.

3. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107/C 1107M, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.
4. Metal Panel Sealants:
 - a. Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyisobutylene-compound sealant tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape of manufacturer's standard size.
 - b. Joint Sealant: ASTM C 920; one part elastomeric polyurethane or polysulfide; of type, grade, class, and use classifications required to seal joints in metal panels and remain weathertight; and as recommended by metal building system manufacturer.

2.10 FABRICATION

- A. General: Design components and field connections required for erection to permit easy assembly.
 1. Mark each piece and part of the assembly to correspond with previously prepared erection drawings, diagrams, and instruction manuals.
 2. Fabricate structural framing to produce clean, smooth cuts and bends. Punch holes of proper size, shape, and location. Members shall be free of cracks, tears, and ruptures.
- B. Tolerances: Comply with MBMA's "Metal Building Systems Manual" for fabrication and erection tolerances.
- C. Primary Framing: Shop fabricate framing components to indicated size and section, with baseplates, bearing plates, stiffeners, and other items required for erection welded into place. Cut, form, punch, drill, and weld framing for bolted field assembly.
 1. Make shop connections by welding or by using high-strength bolts.
 2. Join flanges to webs of built-up members by a continuous, submerged arc-welding process.
 3. Brace compression flange of primary framing with steel angles or cold-formed structural tubing between frame web and purlin web or girt web, so flange compressive strength is within allowable limits for any combination of loadings.
 4. Weld clips to frames for attaching secondary framing if applicable, or punch for bolts.
 5. Shop Priming: Prepare surfaces for shop priming according to SSPC-SP 2. Shop prime primary framing with specified primer after fabrication.
- D. Secondary Framing: Shop fabricate framing components to indicated size and section by roll forming or break forming, with baseplates, bearing plates, stiffeners, and other plates required for erection welded into place. Cut, form, punch, drill, and weld secondary framing for bolted field connections to primary framing.
 1. Make shop connections by welding or by using non-high-strength bolts.
 2. Shop Priming: Prepare uncoated surfaces for shop priming according to SSPC-SP 2. Shop prime uncoated secondary framing with specified primer after fabrication.

- E. Metal Panels: Fabricate and finish metal panels at the factory to greatest extent possible, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements. Comply with indicated profiles and with dimensional and structural requirements.
 - 1. Provide panel profile, including major ribs and intermediate stiffening ribs, if any, for full length of metal panel.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with erector present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Before erection proceeds, survey elevations and locations of concrete- and masonry-bearing surfaces and locations of anchor rods, bearing plates, and other embedments to receive structural framing, with erector present, for compliance with requirements and metal building system manufacturer's tolerances.
 - 1. Engage land surveyor to perform surveying.
- C. Proceed with erection only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Clean and prepare surfaces to be painted according to manufacturer's written instructions for each particular substrate condition.
- B. Provide temporary shores, guys, braces, and other supports during erection to keep structural framing secure, plumb, and in alignment against temporary construction loads and loads equal in intensity to design loads. Remove temporary supports when permanent structural framing, connections, and bracing are in place unless otherwise indicated.

3.3 ERECTION OF STRUCTURAL FRAMING

- A. Erect metal building system according to manufacturer's written instructions and drawings.
- B. Do not field cut, drill, or alter structural members without written approval from metal building system manufacturer's professional engineer.
- C. Set structural framing accurately in locations and to elevations indicated, according to AISC specifications referenced in this Section. Maintain structural stability of frame during erection.

- D. Base and Bearing Plates: Clean concrete- and masonry-bearing surfaces of bond-reducing materials, and roughen surfaces prior to setting plates. Clean bottom surface of plates.
 - 1. Set plates for structural members on wedges, shims, or setting nuts as required.
 - 2. Tighten anchor rods after supported members have been positioned and plumbed. Do not remove wedges or shims but, if protruding, cut off flush with edge of plate before packing with grout.
 - 3. Promptly pack grout solidly between bearing surfaces and plates so no voids remain. Neatly finish exposed surfaces; protect grout and allow to cure. Comply with manufacturer's written installation instructions for shrinkage-resistant grouts.
- E. Align and adjust structural framing before permanently fastening. Before assembly, clean bearing surfaces and other surfaces that will be in permanent contact with framing. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.
 - 1. Level and plumb individual members of structure.
 - 2. Make allowances for difference between temperature at time of erection and mean temperature when structure will be completed and in service.
- F. Primary Framing and End Walls: Erect framing level, plumb, rigid, secure, and true to line. Level baseplates to a true even plane with full bearing to supporting structures, set with double-nutted anchor bolts. Use grout to obtain uniform bearing and to maintain a level base-line elevation. Moist-cure grout for not less than seven days after placement.
 - 1. Make field connections using high-strength bolts installed according to RCSC's "Specification for Structural Joints Using High-Strength Bolts" for bolt type and joint type specified.
 - a. Joint Type: Snug tightened or pretensioned as required by manufacturer.
- G. Secondary Framing: Erect framing level, plumb, rigid, secure, and true to line. Field bolt secondary framing to clips attached to primary framing.
 - 1. Provide rake or gable purlins with tight-fitting closure channels and fasciae.
 - 2. Locate and space wall girts to suit openings such as doors and windows.
 - 3. Provide supplemental framing at entire perimeter of openings, including doors, windows, louvers, ventilators, and other penetrations of roof and walls.
- H. Bracing: Install bracing in roof and sidewalls where indicated on erection drawings.
 - 1. Tighten rod and cable bracing to avoid sag.
 - 2. Locate interior end-bay bracing only where indicated.
- I. Framing for Openings: Provide shapes of proper design and size to reinforce openings and to carry loads and vibrations imposed, including equipment furnished under mechanical and electrical work. Securely attach to structural framing.
- J. Erection Tolerances: Maintain erection tolerances of structural framing within AISC 303.

3.4 METAL PANEL INSTALLATION, GENERAL

- A. Fabricate and finish metal panels and accessories at the factory, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements demonstrated by laboratory testing. Comply with indicated profiles and with dimensional and structural requirements.
- B. On-Site Fabrication: Subject to compliance with requirements of this Section, metal panels may be fabricated on-site using UL-certified, portable roll-forming equipment if panels are of same profile and warranted by manufacturer to be equal to factory-formed panels. Fabricate according to equipment manufacturer's written instructions and to comply with details shown.
- C. Examination: Examine primary and secondary framing to verify that structural-panel support members and anchorages have been installed within alignment tolerances required by manufacturer.
 - 1. Examine roughing-in for components and systems penetrating metal panels, to verify actual locations of penetrations relative to seams before metal panel installation.
- D. General: Anchor metal panels and other components of the Work securely in place, with provisions for thermal and structural movement.
 - 1. Field cut metal panels as required for doors, windows, and other openings. Cut openings as small as possible, neatly to size required, and without damage to adjacent metal panel finishes.
 - a. Field cutting of metal panels by torch is not permitted unless approved in writing by manufacturer.
 - 2. Install metal panels perpendicular to structural supports unless otherwise indicated.
 - 3. Flash and seal metal panels with weather closures at perimeter of openings and similar elements. Fasten with self-tapping screws.
 - 4. Locate and space fastenings in uniform vertical and horizontal alignment.
 - 5. Locate metal panel splices over structural supports with end laps in alignment.
 - 6. Lap metal flashing over metal panels to allow moisture to run over and off the material.
- E. Lap-Seam Metal Panels: Install screw fasteners using power tools with controlled torque adjusted to compress EPDM washers tightly without damage to washers, screw threads, or metal panels. Install screws in predrilled holes.
 - 1. Arrange and nest side-lap joints so prevailing winds blow over, not into, lapped joints. Lap ribbed or fluted sheets one full rib corrugation. Apply metal panels and associated items for neat and weathertight enclosure. Avoid "panel creep" or application not true to line.
- F. Metal Protection: Where dissimilar metals contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with corrosion-resistant coating, by applying rubberized-asphalt underlayment to each contact surface, or by other permanent separation as recommended by metal roof panel manufacturer.

- G. Joint Sealers: Install gaskets, joint fillers, and sealants where indicated and where required for weatherproof performance of metal panel assemblies. Provide types of gaskets, fillers, and sealants indicated; or, if not indicated, provide types recommended by metal panel manufacturer.
 - 1. Seal metal panel end laps with double beads of tape or sealant the full width of panel. Seal side joints where recommended by metal panel manufacturer.
 - 2. Prepare joints and apply sealants to comply with requirements in Section 079200 "Joint Sealants."

3.5 METAL ROOF PANEL INSTALLATION

- A. General: Provide metal roof panels of full length from eave to ridge unless otherwise indicated or restricted by shipping limitations.
 - 1. Install ridge caps as metal roof panel work proceeds.
 - 2. Flash and seal metal roof panels with weather closures at eaves and rakes. Fasten with self-tapping screws.
- B. Standing-Seam Metal Roof Panels: Fasten metal roof panels to supports with concealed clips at each standing-seam joint, at location and spacing and with fasteners recommended by manufacturer.
 - 1. Install clips to supports with self-drilling or self-tapping fasteners.
 - 2. Install pressure plates at locations indicated in manufacturer's written installation instructions.
 - 3. Snap Joint: Nest standing seams and fasten together by interlocking and completely engaging factory-applied sealant.
 - 4. Seamed Joint: Crimp standing seams with manufacturer-approved motorized seamer tool so that clip, metal roof panel, and factory-applied sealant are completely engaged.
 - 5. Rigidly fasten eave end of metal roof panels and allow ridge end free movement for thermal expansion and contraction. Predrill panels for fasteners.
 - 6. Provide metal closures at peaks rake edges rake walls and each side of ridge caps.
- C. Metal Fascia Panels: Align bottom of metal panels and fasten with blind rivets, bolts, or self-drilling or self-tapping screws. Flash and seal metal panels with weather closures where fasciae meet soffits, along lower panel edges, and at perimeter of all openings.
- D. Metal Roof Panel Installation Tolerances: Shim and align metal roof panels within installed tolerance of 1/4 inch in 20 feet on slope and location lines and within 1/8-inch offset of adjoining faces and of alignment of matching profiles.

3.6 METAL WALL PANEL INSTALLATION

- A. General: Install metal wall panels in orientation, sizes, and locations indicated on Drawings. Install panels perpendicular to girts, extending full height of building, unless otherwise indicated. Anchor metal wall panels and other components of the Work securely in place, with provisions for thermal and structural movement.
 - 1. Unless otherwise indicated, begin metal panel installation at corners with center of rib lined up with line of framing.

2. Shim or otherwise plumb substrates receiving metal wall panels.
3. When two rows of metal panels are required, lap panels 4 inches minimum.
4. When building height requires two rows of metal panels at gable ends, align lap of gable panels over metal wall panels at eave height.
5. Rigidly fasten base end of metal wall panels and allow eave end free movement for thermal expansion and contraction. Predrill panels.
6. Flash and seal metal wall panels with weather closures at eaves and rakes, and at perimeter of all openings. Fasten with self-tapping screws.
7. Install screw fasteners in predrilled holes.
8. Install flashing and trim as metal wall panel work proceeds.
9. Apply elastomeric sealant continuously between metal base channel (sill angle) and concrete, and elsewhere as indicated on Drawings; if not indicated, as necessary for waterproofing.
10. Align bottom of metal wall panels and fasten with blind rivets, bolts, or self-drilling or self-tapping screws.
11. Provide weatherproof escutcheons for pipe and conduit penetrating exterior walls.

B. Metal Wall Panels: Install metal wall panels on exterior side of girts. Attach metal wall panels to supports with fasteners as recommended by manufacturer.

C. Installation Tolerances: Shim and align metal wall panels within installed tolerance of 1/4 inch in 20 feet, noncumulative; level, plumb, and on location lines; and within 1/8-inch offset of adjoining faces and of alignment of matching profiles.

3.7 METAL SOFFIT PANEL INSTALLATION

A. Provide metal soffit panels the full width of soffits. Install panels perpendicular to support framing.

B. Flash and seal metal soffit panels with weather closures where panels meet walls and at perimeter of all openings.

3.8 THERMAL INSULATION INSTALLATION

A. General: Install insulation concurrently with metal panel installation, in thickness indicated to cover entire surface, according to manufacturer's written instructions.

1. Set vapor-retarder-faced units with vapor retarder toward warm side of construction unless otherwise indicated. Do not obstruct ventilation spaces except for firestopping.
2. Tape joints and ruptures in vapor retarder, and seal each continuous area of insulation to the surrounding construction to ensure airtight installation.
3. Install blankets straight and true in one-piece lengths. Install vapor retarder over insulation, with both sets of facing tabs sealed, to provide a complete vapor retarder.

B. Blanket Roof Insulation: Comply with the following installation method:

1. Two-Layers-between-Purlin-with-Spacer-Block Installation: Extend insulation and vapor retarder between purlins. Carry vapor-retarder-facing tabs up and over

- purlin, overlapping adjoining facing of next insulation course and maintaining continuity of retarder. Install layer of filler insulation over first layer to fill space between purlins formed by thermal spacer blocks. Hold in place with bands and crossbands below insulation.
- a. Thermal Spacer Blocks: Where metal roof panels attach directly to purlins, install thermal spacer blocks.
 2. Retainer Strips: Install retainer strips at each longitudinal insulation joint, straight and taut, nesting with secondary framing to hold insulation in place.
- C. Blanket Wall Insulation: Extend insulation and vapor retarder over and perpendicular to top flange of secondary framing. Hold in place by metal wall panels fastened to secondary framing.
1. Retainer Strips: Install retainer strips at each longitudinal insulation joint, straight and taut, nesting with secondary framing to hold insulation in place.
 2. Sound-Absorption Insulation: Where sound-absorption requirement is indicated for metal liner panels, cover insulation with polyethylene film and provide inserts of wire mesh to form acoustical spacer grid.

3.9 ACCESSORY INSTALLATION

- A. General: Install accessories with positive anchorage to building and weathertight mounting, and provide for thermal expansion. Coordinate installation with flashings and other components.
1. Install components required for a complete metal roof panel assembly, including trim, copings, ridge closures, seam covers, flashings, sealants, gaskets, fillers, closure strips, and similar items.
 2. Install components for a complete metal wall panel assembly, including trim, copings, corners, seam covers, flashings, sealants, gaskets, fillers, closure strips, and similar items.
 3. Where dissimilar metals contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with corrosion-resistant coating, by applying rubberized-asphalt underlayment to each contact surface, or by other permanent separation as recommended by manufacturer.
- B. Flashing and Trim: Comply with performance requirements, manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, and set units true to line and level. Install work with laps, joints, and seams that will be permanently watertight and weather resistant.
1. Install exposed flashing and trim that is without excessive oil-canning, buckling, and tool marks and that is true to line and levels indicated, with exposed edges folded back to form hems. Install sheet metal flashing and trim to fit substrates and to result in waterproof and weather-resistant performance.
 2. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at a maximum of 10 feet with no joints allowed within 24 inches of corner or intersection. Where lapped or bayonet-type expansion provisions cannot be used or would not be sufficiently weather resistant and waterproof, form expansion joints of intermeshing hooked flanges, not less than 1 inch deep, filled with mastic sealant (concealed within joints).

- C. Gutters: Join sections with riveted-and-soldered or lapped-and-sealed joints. Attach gutters to eave with gutter hangers spaced as required for gutter size, but not more than 36 inches o.c. using manufacturer's standard fasteners. Provide end closures and seal watertight with sealant. Provide for thermal expansion.
- D. Downspouts: Join sections with 1-1/2-inch telescoping joints. Provide fasteners designed to hold downspouts securely 1 inch away from walls; locate fasteners at top and bottom and at approximately 60 inches o.c. in between.
 - 1. Provide elbows at base of downspouts to direct water away from building.
- E. Continuous Roof Ventilators: Set ventilators complete with necessary hardware, anchors, dampers, weather guards, rain caps, and equipment supports. Join sections with splice plates and end-cap skirt assemblies where required to achieve indicated length. Install preformed filler strips at base to seal ventilator to metal roof panels.
- F. Louvers: Locate and place louver units level, plumb, and at indicated alignment with adjacent work.
 - 1. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.
 - 2. Provide perimeter reveals and openings of uniform width for sealants and joint fillers.
 - 3. Protect galvanized- and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of corrosion-resistant paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.
 - 4. Install concealed gaskets, flashings, joint fillers, and insulation as louver installation progresses, where weathertight louver joints are required. Comply with Section 079200 "Joint Sealants" for sealants applied during louver installation.
- G. Roof Curbs: Install curbs at locations indicated on Drawings. Install flashing around bases where they meet metal roof panels.
- H. Pipe Flashing: Form flashing around pipe penetration and metal roof panels. Fasten and seal to panel as recommended by manufacturer.

3.10 ADJUSTING

- A. Roof Ventilators and Adjustable Louvers: After completing installation, including work by other trades, lubricate, test, and adjust units to operate easily, free of warp, twist, or distortion as needed to provide fully functioning units.
 - 1. Adjust louver blades to be weathertight when in closed position.

3.11 CLEANING AND PROTECTION

- A. Repair damaged galvanized coatings on galvanized items with galvanized repair paint according to ASTM A 780/A 780M and manufacturer's written instructions.

- B. Remove and replace glass that has been broken, chipped, cracked, abraded, or damaged during construction period.
- C. Touchup Painting: After erection, promptly clean, prepare, and prime or reprime field connections, rust spots, and abraded surfaces of prime-painted structural framing, bearing plates, and accessories.
 - 1. Clean and prepare surfaces by SSPC-SP 2, "Hand Tool Cleaning," or by SSPC-SP 3, "Power Tool Cleaning."
 - 2. Apply a compatible primer of same type as shop primer used on adjacent surfaces.
- D. Touchup Painting: Cleaning and touchup painting are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."
- E. Metal Panels: Remove temporary protective coverings and strippable films, if any, as metal panels are installed. On completion of metal panel installation, clean finished surfaces as recommended by metal panel manufacturer. Maintain in a clean condition during construction.
 - 1. Replace metal panels that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.
- F. Louvers: Clean exposed surfaces that are not protected by temporary covering, to remove fingerprints and soil during construction period. Do not let soil accumulate until final cleaning.
 - 1. Restore louvers damaged during installation and construction period so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Architect, remove damaged units and replace with new units.
 - a. Touch up minor abrasions in finishes with air-dried coating that matches color and gloss of, and is compatible with, factory-applied finish coating.

END OF SECTION 13 34 19

Special Specification RMA9

**Section 230529FL; 230593FL; 230713FL; 233113FL; 233300FL;
233713.13FL; 238129FL**

**TAB-Units-1st/TAB-Units-Additional/TAB-Airflow/Ductwork/VRF
System-3 tons/ERV/Controls/Piping-Refrigerant/Piping-
Condensate/Heaters-Hangar**

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Equipment stands.
- B. Related Requirements:
 - 1. Section 233113 "Metal Ducts" for duct hangers and supports.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Show fabrication and installation details and include calculations for the following; include Product Data for components:
 - 1. Equipment supports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
 - 1. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

2.2 OUTDOOR EQUIPMENT STANDS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. MIRO Industries.
 - 2. RectorSeal HVAC; a CSW Industrials Company.

2.3 MATERIALS

- A. Aluminum: ASTM B221.
- B. Carbon Steel: ASTM A1011/A1011M.
- C. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; galvanized.
- D. Stainless Steel: ASTM A240/A240M.
- E. Threaded Rods: Continuously threaded. Zinc-plated or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar materials as rods.
- F. Grout: ASTM C1107/C1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

END OF SECTION 230529

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Testing, Adjusting, and Balancing of Air Systems:
 - a. Constant-volume air systems.
 - 2. Testing, adjusting, and balancing of equipment.
 - 3. Duct leakage tests verification.

1.3 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. NEBB: National Environmental Balancing Bureau.
- C. TAB: Testing, adjusting, and balancing.
- D. TABB: Testing, Adjusting, and Balancing Bureau.
- E. TAB Specialist: An independent entity meeting qualifications to perform TAB work.
- F. TDH: Total dynamic head.
- G. UFAD: Underfloor air distribution.

1.4 PREINSTALLATION MEETINGS

- A. TAB Conference: Conduct a TAB conference at [**Project site**] <**Insert location**> after approval of the TAB strategies and procedures plan, to develop a mutual understanding of the details. Provide a minimum of [**14**] <**Insert number**> days' advance notice of scheduled meeting time and location.
 - 1. Minimum Agenda Items:
 - a. The Contract Documents examination report.
 - b. The TAB plan.
 - c. Needs for coordination and cooperation of trades and subcontractors.
 - d. Proposed procedures for documentation and communication flow.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report, as specified in Part 3.
- C. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures, as specified in "Preparation" Article.
- D. System Readiness Checklists: Within 30 days of Contractor's Notice to Proceed, submit system readiness checklists, as specified in "Preparation" Article.
- E. Examination Report: Submit a summary report of the examination review required in "Examination" Article.
- F. Certified TAB reports.
- G. Sample report forms.
- H. Instrument calibration reports, to include the following:
 - 1. Instrument type and make.
 - 2. Serial number.
 - 3. Application.
 - 4. Dates of use.
 - 5. Dates of calibration.

1.6 QUALITY ASSURANCE

- A. TAB Specialists Qualifications, Certified by AABC:
 - 1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
 - 2. TAB Technician: Employee of the TAB specialist and certified by AABC.
- B. TAB Specialists Qualifications, Certified by NEBB or TABB:
 - 1. TAB Field Supervisor: Employee of the TAB specialist and certified by NEBB or TABB.
 - 2. TAB Technician: Employee of the TAB specialist and certified by NEBB or TABB.
- C. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."
- E. Code and AHJ Compliance: TAB is required to comply with governing codes and requirements of authorities having jurisdiction.

1.7 FIELD CONDITIONS

- A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.
- B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.
- B. Examine installed systems for balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine ceiling plenums and underfloor air plenums used for HVAC to verify that they are properly separated from adjacent areas and sealed.
- F. Examine equipment performance data, including fan and pump curves.
 - 1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
 - 2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.
- G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- H. Examine test reports specified in individual system and equipment Sections.

- I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.
- J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.
- K. Examine temporary and permanent strainers. Verify that temporary strainer screens used during system cleaning and flushing have been removed and permanent strainer baskets are installed and clean.
- L. Examine control valves for proper installation for their intended function of isolating, throttling, diverting, or mixing fluid flows.
- M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- N. Examine system pumps to ensure absence of entrained air in the suction piping.
- O. Examine operating safety interlocks and controls on HVAC equipment.
- P. Examine control dampers for proper installation for their intended function of isolating, throttling, diverting, or mixing air flows.
- Q. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

- A. Prepare a TAB plan that includes the following:
 - 1. Equipment and systems to be tested.
 - 2. Strategies and step-by-step procedures for balancing the systems.
 - 3. Instrumentation to be used.
 - 4. Sample forms with specific identification for all equipment.
- B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
 - 1. Airside:
 - a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
 - b. Duct systems are complete with terminals installed.
 - c. Volume, smoke, and fire dampers are open and functional.
 - d. Clean filters are installed.
 - e. Fans are operating, free of vibration, and rotating in correct direction.
 - f. Variable-frequency controllers' startup is complete and safeties are verified.
 - g. Automatic temperature-control systems are operational.
 - h. Ceilings are installed.
 - i. Windows and doors are installed.
 - j. Suitable access to balancing devices and equipment is provided.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system in accordance with the procedures contained in AABC's "National Standards for Total System Balance" and in this Section.
- B. Cut insulation, ducts, pipes, and equipment casings for installation of test probes to the minimum extent necessary for TAB procedures.
 - 1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
 - 2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
 - 3. Where holes for probes are required in piping or hydronic equipment, install pressure and temperature test plugs to seal systems.
 - 4. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish in accordance with Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."
- C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 TESTING, ADJUSTING, AND BALANCING OF HVAC EQUIPMENT

- A. Test, adjust, and balance HVAC equipment indicated on Drawings, including, but not limited to, the following:
 - 1. Motors.
 - 2. Fans and ventilators.
 - 3. Condensing units.
 - 4. Air-handling units.
 - 5. Split-system air conditioners.
 - 6. Heat pumps.
 - 7. Unit ventilators.

3.5 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' Record drawings duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling-unit components.

3.6 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 - 1. Measure total airflow.
 - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
 - b. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.
 - c. Where duct conditions are unsuitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
 - 2. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - b. Measure static pressure directly at the fan inlet or through the flexible connection.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report artificial loading of filters at the time static pressures are measured.
 - 3. Review Contractor-prepared shop drawings and Record drawings to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
 - 4. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
 - 5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
 - 1. Measure airflow of submain and branch ducts.
 - 2. Adjust submain and branch duct volume dampers for specified airflow.
 - 3. Re-measure each submain and branch duct after all have been adjusted.
- C. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
 2. Measure inlets and outlets airflow.
 3. Adjust each inlet and outlet for specified airflow.
 4. Re-measure each inlet and outlet after they have been adjusted.
- D. Verify final system conditions.
1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
 2. Re-measure and confirm that total airflow is within design.
 3. Re-measure all final fan operating data, speed, volts, amps, and static profile.
 4. Mark all final settings.
 5. Test system in economizer mode. Verify proper operation and adjust if necessary.
 6. Measure and record all operating data.
 7. Record final fan-performance data.

3.7 PROCEDURES FOR AIR-COOLED CONDENSING UNITS

- A. Verify proper rotation of fan(s).
- B. Measure and record entering- and leaving-air temperatures.
- C. Measure and record entering and leaving refrigerant pressures.
- D. Measure and record operating data of compressor(s), fan(s), and motors.

3.8 DUCT LEAKAGE TESTS

- A. Witness the duct leakage testing performed by Installer.
- B. Verify that proper test methods are used and that leakage rates are within specified limits.
- C. Report deficiencies observed.

3.9 HVAC CONTROLS VERIFICATION

- A. In conjunction with system balancing, perform the following:
 1. Verify HVAC control system is operating within the design limitations.
 2. Confirm that the sequences of operation are in compliance with Contract Documents.
 3. Verify that controllers are calibrated and function as intended.
 4. Verify that controller set points are as indicated.
 5. Verify the operation of lockout or interlock systems.
 6. Verify the operation of valve and damper actuators.
 7. Verify that controlled devices are properly installed and connected to correct controller.
 8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
 9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

- B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.10 TOLERANCES

- A. Set HVAC system's airflow rates and water flow rates within the following tolerances:
 - 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent . If design value is less than 100 cfm, within 10 cfm.
 - 2. Air Outlets and Inlets: Plus or minus 10 percent. If design value is less than 100 cfm, within 10 cfm.
- B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.11 PROGRESS REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for system-balancing devices. Recommend changes and additions to system-balancing devices, to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance-measuring and -balancing devices.
- B. Status Reports: Prepare biweekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.12 FINAL REPORT

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
 - 1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
 - 2. Include a list of instruments used for procedures, along with proof of calibration.
 - 3. Certify validity and accuracy of field data.
- B. Final Report Contents: In addition to certified field-report data, include the following:
 - 1. Manufacturers' test data.
 - 2. Field test reports prepared by system and equipment installers.
 - 3. Other information relative to equipment performance; do not include Shop Drawings and Product Data.
- C. General Report Data: In addition to form titles and entries, include the following data:
 - 1. Title page.
 - 2. Name and address of the TAB specialist.
 - 3. Project name.
 - 4. Project location.
 - 5. Architect's name and address.

6. Engineer's name and address.
 7. Contractor's name and address.
 8. Report date.
 9. Signature of TAB supervisor who certifies the report.
 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 11. Summary of contents, including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 12. Nomenclature sheets for each item of equipment.
 13. Data for terminal units, including manufacturer's name, type, size, and fittings.
 14. Notes to explain why certain final data in the body of reports vary from indicated values.
 15. Test conditions for fans performance forms, including the following:
 - a. Settings for outdoor-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Heating coil, dry-bulb conditions.
 - e. Face and bypass damper settings at coils.
 - f. Fan drive settings, including settings and percentage of maximum pitch diameter.
 - g. Inlet vane settings for variable-air-volume systems.
 - h. Settings for pressure controller(s).
 - i. Other system operating conditions that affect performance.
 16. Test conditions for pump performance forms, including the following:
 - a. Variable-frequency controller settings for variable-flow hydronic systems.
 - b. Settings for pressure controller(s).
 - c. Other system operating conditions that affect performance.
- D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
1. Quantities of outdoor, supply, return, and exhaust airflows.
 2. Water and steam flow rates.
 3. Duct, outlet, and inlet sizes.
 4. Pipe and valve sizes and locations.
 5. Terminal units.
 6. Balancing stations.
 7. Position of balancing devices.
- E. Air-Handling-Unit Test Reports: For air-handling units, include the following:
1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Unit arrangement and class.
 - g. Discharge arrangement.
 - h. Sheave make, size in inches, and bore.
 - i. Center-to-center dimensions of sheave and amount of adjustments in inches.

- j. Number, make, and size of belts.
 - k. Number, type, and size of filters.
 - 2. Motor Data:
 - a. Motor make, and frame type and size.
 - b. Horsepower and speed.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Center-to-center dimensions of sheave and amount of adjustments in inches.
 - 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan speed.
 - d. Inlet and discharge static pressure in inches wg.
 - e. For each filter bank, filter static-pressure differential in inches wg.
 - f. Preheat-coil static-pressure differential in inches wg.
 - g. Cooling-coil static-pressure differential in inches wg.
 - h. Heating-coil static-pressure differential in inches wg.
 - i. List for each internal component with pressure-drop, static-pressure differential in inches wg.
 - j. Outdoor airflow in cfm.
 - k. Return airflow in cfm.
 - l. Outdoor-air damper position.
- F. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
 - 1. Report Data:
 - a. System fan and air-handling-unit number.
 - b. Location and zone.
 - c. Traverse air temperature in deg F.
 - d. Duct static pressure in inches wg.
 - e. Duct size in inches.
 - f. Duct area in sq. ft..
 - g. Indicated airflow rate in cfm.
 - h. Indicated velocity in fpm.
 - i. Actual airflow rate in cfm.
 - j. Actual average velocity in fpm.
 - k. Barometric pressure in psig.
- G. Air-Terminal-Device Reports:
 - 1. Unit Data:
 - a. System and air-handling unit identification.
 - b. Location and zone.
 - c. Apparatus used for test.
 - d. Area served.
 - e. Make.
 - f. Number from system diagram.
 - g. Type and model number.
 - h. Size.
 - i. Effective area in sq. ft..

2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Air velocity in fpm.
 - c. Preliminary airflow rate as needed in cfm.
 - d. Preliminary velocity as needed in fpm.
 - e. Final airflow rate in cfm.
 - f. Final velocity in fpm.
 - g. Space temperature in deg F.

3.13 VERIFICATION OF TAB REPORT

- A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Construction Manager.
- B. Construction Manager shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to the lesser of either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
- C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
- D. If the number of "FAILED" measurements is greater than 20 percent of the total measurements checked during the final inspection, the TAB shall be considered incomplete and shall be rejected.
- E. If recheck measurements find the number of failed measurements noncompliant with requirements indicated, proceed as follows:
 1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection. All changes shall be tracked to show changes made to previous report.
 2. If the second final inspection also fails, Owner may pursue others Contract options to complete TAB work.
- F. Prepare test and inspection reports.

3.14 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
- B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 230593

SECTION 230713 - DUCT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes insulating the following duct services:
 - 1. Indoor, concealed supply and outdoor air.
 - 2. Indoor, exposed supply and outdoor air.
 - 3. Indoor, concealed return located in unconditioned space.
 - 4. Indoor, exposed return located in unconditioned space.
 - 5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
 - 6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
- B. Related Requirements:
 - 1. Section 233113 "Metal Ducts" for duct liners.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
 - 3. Detail application of field-applied jackets.
 - 4. Detail application at linkages of control devices.
- C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:
 - 1. Sheet Form Insulation Materials: 12 inches square.
 - 2. Sheet Jacket Materials: 12 inches square.
 - 3. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
- C. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or craft training program, certified by the Department of Labor, Bureau of Apprenticeship and Training.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers are to be marked with the manufacturer's name, appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.
 - 1. All Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2.2 INSULATION MATERIALS

- A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials are to be applied.
- B. Products do not contain asbestos, lead, mercury, or mercury compounds.

- C. Products that come in contact with stainless steel have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.
- D. Insulation materials for use on austenitic stainless steel are qualified as acceptable in accordance with ASTM C795.
- E. Foam insulation materials do not use CFC or HCFC blowing agents in the manufacturing process.
- F. Flexible Elastomeric: Closed-cell or expanded-rubber materials; suitable for maximum use temperature between minus 70 deg F and 220 deg F. Comply with ASTM C534, Type II for sheet materials.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aeroflex USA.
 - b. Armacell LLC.
 - c. K-Flex USA.
- G. Glass-Fiber Blanket: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 450 deg F in accordance with ASTM C411. Comply with ASTM C553, Type II, and ASTM C1290, [Type I, unfaced] [Type II with factory-applied vinyl jacket] [Type III with factory-applied FSK jacket] [Type III with factory-applied FSP jacket]. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide [product indicated on Drawings] <insert manufacturer name, product name or designation> or comparable product by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Certainteed; SAINT-GOBAIN.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. Knauf Insulation.
 - d. Manson Insulation Inc.
 - e. Owens Corning.

2.3 ADHESIVES

- A. Materials are compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aeroflex USA.

- b. Armacell LLC.
 - c. Childers Brand; H. B. Fuller Construction Products.
 - d. Foster Brand; H. B. Fuller Construction Products.
 - e. K-Flex USA.
- C. Glass-Fiber and Mineral Wool Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide [**product indicated on Drawings**] <insert manufacturer name, product name or designation> or comparable product by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Eagle Bridges - Marathon Industries.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. Mon-Eco Industries, Inc.
- D. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Eagle Bridges - Marathon Industries.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. Mon-Eco Industries, Inc.

2.4 LAGGING ADHESIVES

- A. Description: Comply with MIL-A-3316C, Class I, Grade A and are compatible with insulation materials, jackets, and substrates.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Vimasco Corporation.
 - 3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
 - 4. Service Temperature Range: 0 to plus 180 deg F.
 - 5. Color: White.

2.5 SEALANTS

- A. FSK and Metal Jacket Flashing Sealants:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Eagle Bridges - Marathon Industries.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. Mon-Eco Industries, Inc.
3. Materials are compatible with insulation materials, jackets, and substrates.
4. Fire- and water-resistant, flexible, elastomeric sealant.
5. Service Temperature Range: Minus 40 to plus 250 deg F.
6. Color: Aluminum.

B. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
3. Materials are compatible with insulation materials, jackets, and substrates.
4. Fire- and water-resistant, flexible, elastomeric sealant.
5. Service Temperature Range: Minus 40 to plus 250 deg F.
6. Color: White.

2.6 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
 3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
 4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.
 5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested in accordance with ASTM E96/E96M, Procedure A, and complying with NFPA 90A and NFPA 90B.
 6. ASJ+: All-service jacket composed of aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film leaving no paper exposed; complying with ASTM C1136, Types I, II, III, IV, and VII.
 7. PSK Jacket: Aluminum foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.

2.7 FIELD-APPLIED JACKETS

- A. Field-applied jackets comply with ASTM C921, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
- C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. P.I.C. Plastics, Inc.
 - c. Proto Corporation.
 - d. Speedline Corporation.
 - 3. Adhesive: As recommended by jacket material manufacturer.
 - 4. Color: White.
- D. Self-Adhesive Indoor/Outdoor Jacket (Non-Asphaltic): Vapor barrier and waterproofing jacket for installation over insulation located aboveground outdoors or indoors. Specialized jacket has five layers of laminated aluminum and polyester film with low-temperature acrylic pressure-sensitive adhesive. Outer aluminum surface is coated with UV-resistant coating for protection from environmental contaminants.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. H.B. Fuller Construction Products Inc.
 - d. Ideal Tape Co., Inc., an American Biltrite Company.
 - 3. Permeance: 0.00 perm as tested in accordance with ASTM F1249.
 - 4. Flamespread/Smoke Developed: 25/50 as tested in accordance with ASTM E84.
 - 5. Aluminum Finish: Embossed.

2.8 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M Industrial Adhesives and Tapes Division.
 - b. Avery Dennison Corporation, Specialty Tapes Division.

- c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
 - 3. Width: 3 inches.
 - 4. Thickness: 11.5 mils.
 - 5. Adhesion: 90 ounces force/inch in width.
 - 6. Elongation: 2 percent.
 - 7. Tensile Strength: 40 lbf/inch in width.
 - 8. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M Industrial Adhesives and Tapes Division.
 - b. Avery Dennison Corporation, Specialty Tapes Division.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
 - 3. Width: 3 inches.
 - 4. Thickness: 6.5 mils.
 - 5. Adhesion: 90 ounces force/inch in width.
 - 6. Elongation: 2 percent.
 - 7. Tensile Strength: 40 lbf/inch in width.
 - 8. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M Industrial Adhesives and Tapes Division.
 - b. Ideal Tape Co., Inc., an American Biltrite Company.
 - 3. Width: 2 inches.
 - 4. Thickness: 6 mils.
 - 5. Adhesion: 64 ounces force/inch in width.
 - 6. Elongation: 500 percent.
 - 7. Tensile Strength: 18 lbf/inch in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M Industrial Adhesives and Tapes Division.
 - b. Avery Dennison Corporation, Specialty Tapes Division.

- c. Ideal Tape Co., Inc., an American Biltrite Company.
- d. Knauf Insulation.
- e. Sekisui Voltek, LLC.
- 3. Width: 2 inches.
- 4. Thickness: 3.7 mils.
- 5. Adhesion: 100 ounces force/inch in width.
- 6. Elongation: 5 percent.
- 7. Tensile Strength: 34 lbf/inch in width.

2.9 SECUREMENTS

A. Bands:

- 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
- 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. RPR Products, Inc.
- 3. Stainless Steel: ASTM A240/A240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide with wing seal or closed seal.
- 4. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.
- 5. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

- 1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
 - a. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Midwest Fasteners, Inc.
 - 4) Nelson Stud Welding.
- 2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
 - a. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AGM Industries, Inc.
 - 2) CL WARD & Family Inc.

- 3) Gemco.
- 4) Midwest Fasteners, Inc.
- 5) Nelson Stud Welding.
3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Midwest Fasteners, Inc.
 - c. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
 - d. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
 - e. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Gemco.
 - 2) Midwest Fasteners, Inc.
 - c. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
 - d. Spindle: Nylon, 0.106-inch- diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
 - e. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Midwest Fasteners, Inc.

- c. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
 - d. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
 - e. Adhesive-backed base with a peel-off protective cover.
- 6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
 - a. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Midwest Fasteners, Inc.
 - 4) Nelson Stud Welding.
 - c. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
- 7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
 - a. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Gemco.
 - 2) Midwest Fasteners, Inc.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.
- D. Wire: [0.080-inch nickel-copper alloy.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. C & F Wire Products.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. RPR Products, Inc.

2.10 CORNER ANGLES

- A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC in accordance with ASTM D1784, Class 16354-C. White or color-coded to match adjacent surface.
- B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum in accordance with ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

- C. Stainless Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel in accordance with ASTM A240/A240M, Type 304 or Type 316.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 - 1. Verify that systems to be insulated have been tested and are free of defects.
 - 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.
- B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Keep insulation materials dry during application and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with Contract Documents.
- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.
- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- K. Install insulation with factory-applied jackets as follows:
1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.
 2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.
- L. Cut insulation in a manner to avoid compressing insulation.
- M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
1. Seal penetrations with flashing sealant.

2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 4. Seal jacket to wall flashing with flashing sealant.
- C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
1. Comply with requirements in Section 078413 "Penetration Firestopping."
- E. Insulation Installation at Floor Penetrations:
1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."
- 3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC AND POLYOLEFIN INSULATION
- A. Comply with manufacturer's written installation instructions and ASTM C1710.
- B. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C. Square and Rectangular Ducts and Plenums:
1. Provide 1/4 inch more per side for a tight, compression fit.
 2. Cut sheet insulation with the following dimensions:
 - a. Width of duct plus 1/4 inch, one piece.
 - b. Height of duct plus 1/4 inch, plus thickness of insulation, two pieces.
 - c. Width of duct plus 1/4 inch, plus two times the thickness of insulation, one piece.
 3. Insulate the bottom of the duct with the sheet from (a) above, then the sides with the two sheets from (b) above, and finally the top of the duct with the sheet from (c) above.
 4. Insulation without self-adhering backing:
 - a. Apply 100 percent coverage of manufacturer adhesive on the metal surface, then the insulation, except for the last 1/4 inch where sheets will butt together.
 - b. Roll sheet down into position.
 - c. Press two sheets together under compression and apply adhesive at the butt joint to seal the two sheets together.
 5. Insulation with self-adhering backing:
 - a. Peel back release paper in 6- to 8-inch increments and line up sheet.
 - b. Press firmly to activate adhesive.
 - c. Align material and continue to line up correctly, pressing firmly while slowly removing release paper.

- d. Allow 1/4-inch overlap for compression at butt joints.
- e. Apply adhesive at the butt joint to seal the two sheets together.
6. Insulate duct brackets following manufacturer's written installation instructions.

D. Circular Ducts:

1. Determine the circumference of the duct, using a strip of insulation the same thickness as to be used.
2. Cut the sheet to the required size.
3. Apply 100 percent coverage of manufacturer adhesive on the metal surface then the insulation.
4. Apply manufacturer adhesive to the cut surfaces along 100 percent of the longitudinal seam. Press together the seam at the ends and then the middle. Close the entire seam starting from the middle.

3.6 INSTALLATION OF GLASS-FIBER AND MINERAL-WOOL INSULATION

- A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
- B. Comply with manufacturer's written installation instructions.
 1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Impale insulation over pins and attach speed washers.
 - f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover

- insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
 6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.
- C. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
 5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.7 FIELD-APPLIED JACKET INSTALLATION

- A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
 - 1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
 - 2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
 - 3. Completely encapsulate insulation with coating, leaving no exposed insulation.
- B. Where FSK jackets are indicated, install as follows:
 - 1. Draw jacket material smooth and tight.
 - 2. Install lap or joint strips with same material as jacket.
 - 3. Secure jacket to insulation with manufacturer's recommended adhesive.
 - 4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
 - 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.
 - 1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless steel bands 12 inches o.c. and at end joints.

3.8 FIRE-RATED INSULATION SYSTEM INSTALLATION

- A. Comply with manufacturer's written installation instructions.
- B. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.
- C. Insulate duct access panels and doors to achieve same fire rating as duct.
- D. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 078413 "Penetration Firestopping."

3.9 FINISHES

- A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."
 - 1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.

- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- D. Do not field paint aluminum or stainless steel jackets.

3.10 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Tests and Inspections:
 - 1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection is limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.
- D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.11 DUCT INSULATION SCHEDULE, GENERAL

- A. Plenums and Ducts Requiring Insulation:
 - 1. Indoor, concealed supply and outdoor air.
 - 2. Indoor, concealed return located in unconditioned space.
 - 3. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
- B. Items Not Insulated:
 - 1. Fibrous-glass ducts.
 - 2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
 - 3. Factory-insulated flexible ducts.
 - 4. Factory-insulated plenums and casings.
 - 5. Flexible connectors.
 - 6. Vibration-control devices.
 - 7. Factory-insulated access panels and doors.

3.12 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

- A. Concealed, round and flat-oval, supply-air duct insulation is one of the following:
 - 1. Flexible Elastomeric: 1 inch thick.
 - 2. Glass-Fiber Blanket: 1-1/2 inches thick and 0.75 lb/cu. ft. nominal density.
- B. Concealed, round and flat-oval, outdoor-air duct insulation is one of the following:
 - 1. Flexible Elastomeric: 1 inch thick.
 - 2. Glass-Fiber Blanket: 1-1/2 inches thick and 0.75 lb/cu. ft. nominal density.

- C. Concealed, round and flat-oval, exhaust-air duct insulation is one of the following:
 - 1. Flexible Elastomeric: 1 inch thick.
 - 2. Glass-Fiber Blanket: 1-1/2 inches thick and 0.75 lb/cu. ft. nominal density.
- D. Concealed, rectangular, supply-air duct insulation is one of the following:
 - 1. Flexible Elastomeric: 1 inch thick.
 - 2. Glass-Fiber Blanket: 1-1/2 inches thick and 0.75 lb/cu. ft. nominal density.
- E. Concealed, rectangular, return-air duct insulation is **one of** the following:
 - 1. Flexible Elastomeric: 1 inch thick.
 - 2. Glass-Fiber Blanket: 1-1/2 inches thick and 0.75 lb/cu. ft. nominal density.
- F. Concealed, supply-air plenum insulation is one of the following:
 - 1. Flexible Elastomeric: 1 inch thick.
 - 2. Glass-Fiber Blanket: 1-1/2 inches thick and 0.75 lb/cu. ft. nominal density.
- G. Concealed, return-air plenum insulation is one of the following:
 - 1. Flexible Elastomeric: 1 inch thick.
 - 2. Glass-Fiber Blanket: 1-1/2 inches thick and 0.75 lb/cu. ft. nominal density.

3.13 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Ducts and Plenums, Concealed:
 - 1. None.
 - 2. PVC: 20 mils thick.
 - 3. Aluminum, Smooth: 0.016 inch thick.
 - 4. Painted Aluminum, Smooth: 0.016 inch thick.
 - 5. Stainless Steel, Type 304 or Type 316, Smooth 2B Finish: 0.010 inch thick.

END OF SECTION 230713

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Single-wall rectangular ducts and fittings.
 - 2. Single-wall round ducts and fittings.
 - 3. Sheet metal materials.
 - 4. Sealants and gaskets.
 - 5. Hangers and supports.
- B. Related Requirements:
 - 1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
 - 2. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.2 DEFINITIONS

- A. OSHPD: Office of Statewide Health Planning and Development (State of California).

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of the following products:
 - 1. Liners and adhesives.
 - 2. Sealants and gaskets.
 - 3. Seismic-restraint devices.
- B. Shop Drawings:
 - 1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
 - 2. Factory- and shop-fabricated ducts and fittings.
 - 3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
 - 4. Elevation of top of ducts.
 - 5. Dimensions of main duct runs from building grid lines.
 - 6. Fittings.
 - 7. Reinforcement and spacing.
 - 8. Seam and joint construction.
 - 9. Penetrations through fire-rated and other partitions.
 - 10. Equipment installation based on equipment being used on Project.
 - 11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
 - 12. Hangers and supports, including methods for duct and building attachment and vibration isolation.
 - 13.

- C. Delegated Design Submittals:
 - 1. Sheet metal thicknesses.
 - 2. Joint and seam construction and sealing.
 - 3. Reinforcement details and spacing.
 - 4. Materials, fabrication, assembly, and spacing of hangers and supports.
 - 5. Design Calculations: Calculations for selecting hangers and supports.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: A single set of plans or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Welding certificates.
- C. Field quality-control reports.

1.5 QUALITY ASSURANCE

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and with performance requirements and design criteria indicated in "Duct Schedule" Article.
- B. Structural Performance: Duct hangers and supports are to withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"
- C. Airstream Surfaces: Surfaces in contact with airstream comply with requirements in ASHRAE 62.1.
- D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."
- E. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
- F. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation or duct wall thickness.

2.2 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
 - 1. Construct ducts of galvanized sheet steel unless otherwise indicated.
 - 2. For ducts exposed to weather, construct of Type 304 stainless steel indicated by manufacturer to be suitable for outdoor installation.
- B. Transverse Joints: Fabricate joints in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. For ducts with longest side less than 36 inches, select joint types in accordance with Figure 2-1.
 - 2. For ducts with longest side 36 inches or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.
- C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SINGLE-WALL ROUND DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
 - 1. Construct ducts of galvanized sheet steel unless otherwise indicated.
 - 2. For ducts exposed to weather, construct of Type 304 stainless steel indicated by manufacturer to be suitable for outdoor installation.
 - 3. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 4. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Elgen Manufacturing.
 - b. GreenSeam.
 - c. Linx Industries; a DMI company (formerly Lindab).
 - d. MKT Metal Manufacturing.
 - e. McGill AirFlow LLC.
 - f. Nordfab Ducting.

- g. SEMCO, LLC; part of FlaktGroup.
 - h. Set Duct Manufacturing.
 - i. Sheet Metal Connectors, Inc.
 - j. Spiral Manufacturing Co., Inc.
 - k. Stamped Fittings Inc.
- B. Source Limitations: Obtain single-wall round ducts and fittings from single manufacturer.
- C. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).
- D. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
- E. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
 - 2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.
- F. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.4 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials are to be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A653/A653M.
 - 1. Galvanized Coating Designation: G60.
 - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. PVC-Coated, Galvanized Sheet Steel: Comply with ASTM A653/A653M.
 - 1. Galvanized Coating Designation: G60.
 - 2. Minimum Thickness for Factory-Applied PVC Coating: 4 mils thick.
 - 3. Coating Materials: Acceptable to authorities having jurisdiction for use on ducts listed and labeled by an NRTL for compliance with UL 181, Class 1.

- D. Carbon-Steel Sheets: Comply with ASTM A1008/A1008M, with oiled, matte finish for exposed ducts.
- E. Stainless Steel Sheets: Comply with ASTM A480/A480M, Type 304 or 316, as indicated in "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish is to be No. 2B, No. 2D, No. 3, or No. 4 as indicated in "Duct Schedule" Article.
- F. Aluminum Sheets: Comply with ASTM B209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.
- G. Factory- or Shop-Applied Antimicrobial Coating:
 - 1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating is to be applied to the exterior surface.
 - 2. Antimicrobial compound is to be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 - 3. Coating containing the antimicrobial compound is to have a hardness of 2H, minimum, when tested in accordance with ASTM D3363.
 - 4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
 - 5. Shop-Applied Coating Color: Black.
 - 6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.
- H. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.
 - 1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- I. Tie Rods: Galvanized steel, 1/4-inch- minimum diameter for lengths 36 inches or less; 3/8-inch- minimum diameter for lengths longer than 36 inches.

2.5 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets are to be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
- B. Two-Part Tape Sealing System:
 - 1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
 - 2. Tape Width: 3 inches.
 - 3. Sealant: Modified styrene acrylic.
 - 4. Water resistant.
 - 5. Mold and mildew resistant.
 - 6. Maximum Static-Pressure Class: 10 inch wg, positive and negative.
 - 7. Service: Indoor and outdoor.
 - 8. Service Temperature: Minus 40 to plus 200 deg F.

9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10 inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Solvent-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Base: Synthetic rubber resin.
3. Solvent: Toluene and heptane.
4. Solids Content: Minimum 60 percent.
5. Shore A Hardness: Minimum 60.
6. Water resistant.
7. Mold and mildew resistant.
8. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
9. Service: Indoor or outdoor.
10. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. Flanged Joint Sealant: Comply with ASTM C920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.

F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

G. Round Duct Joint O-Ring Seals:

1. Seal is to provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and is to be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.6 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

- C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A603.
- E. Steel Cables for Stainless Steel Ducts: Stainless steel complying with ASTM A492.
- F. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- H. Trapeze and Riser Supports:
 - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
 - 2. Supports for Stainless Steel Ducts: Stainless steel shapes and plates.
 - 3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and coordination drawings.
- B. Install ducts in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install ducts in maximum practical lengths with fewest possible joints.
- D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- G. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

- I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.
- J. Install fire] and smoke dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers and specific installation requirements of the damper UL listing.
- K. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.
- L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation.
- M. Elbows: Use long-radius elbows wherever they fit.
 - 1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
 - 2. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.
- N. Branch Connections: Use lateral or conical branch connections.

3.2 DUCT SEALING

- A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- B. Seal ducts at a minimum to the following seal classes in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
 - 1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 2. Outdoor, Supply-Air Ducts: Seal Class A.
 - 3. Outdoor, Exhaust Ducts: Seal Class C.
 - 4. Outdoor, Return-Air Ducts: Seal Class C.
 - 5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
 - 6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
 - 7. Unconditioned Space, Exhaust Ducts: Seal Class C.
 - 8. Unconditioned Space, Return-Air Ducts: Seal Class B.
 - 9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
 - 10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
 - 11. Conditioned Space, Exhaust Ducts: Seal Class B.
 - 12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.3 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Where practical, install concrete inserts before placing concrete.
 - 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
 - 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
 - 5. Do not use powder-actuated concrete fasteners for seismic restraints. Coordinate with Section 230548 "Vibration and Seismic Controls for HVAC."
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
- D. Hangers Exposed to View: Threaded rod and angle or channel supports.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.4 DUCTWORK CONNECTIONS

- A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.5 PAINTING

- A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

3.6 FIELD QUALITY CONTROL

- A. Perform tests and inspections.

- B. Leakage Tests:
1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
 2. Test the following systems:
 - a. Ducts with a Pressure Class Higher Than 3-Inch wg: Test representative duct sections totaling no less than 25 percent of total installed duct area for each designated pressure class.
 - b. Supply Ducts with a Pressure Class of 2- Inch wg or Higher: Test representative duct sections totaling no less than 50 percent of total installed duct area for each designated pressure class.
 - c. Return Ducts with a Pressure Class of 2- Inch wg or Higher: Test representative duct sections totaling no less than 50 percent of total installed duct area for each designated pressure class.
 3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 4. Testing of each duct section is to be performed with access doors, coils, filters, dampers, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.
 5. Test for leaks before applying external insulation.
 6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
 7. Give seven days' advance notice for testing.
- C. Duct System Cleanliness Tests:
1. Visually inspect duct system to ensure that no visible contaminants are present.
 2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness in accordance with "Description of Method 3 - NADCA Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
 - a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media is to not exceed 0.75 mg/100 sq. cm.
- D. Duct system will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.7 DUCT CLEANING

- A. Clean new duct system(s) before testing, adjusting, and balancing.
- B. For cleaning of existing ductwork, see Section 230130.52 "Existing HVAC Air Distribution System Cleaning."
- C. Use duct cleaning methodology as indicated in NADCA ACR.
- D. Use service openings for entry and inspection.
1. Provide openings with access panels appropriate for duct static-pressure and leakage class at dampers, coils, and any other locations where required for inspection and cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and

- liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
 - 2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
 - 3. Remove and reinstall ceiling to gain access during the cleaning process.
- E. Particulate Collection and Odor Control:
- 1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
 - 2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.
- F. Clean the following components by removing surface contaminants and deposits:
- 1. Air outlets and inlets (registers, grilles, and diffusers).
 - 2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
 - 3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
 - 4. Coils and related components.
 - 5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
 - 6. Supply-air ducts, dampers, actuators, and turning vanes.
 - 7. Dedicated exhaust and ventilation components and makeup air systems.
- G. Mechanical Cleaning Methodology:
- 1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
 - 2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
 - 3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
 - 4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
 - 5. Clean coils and coil drain pans in accordance with NADCA ACR. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
 - 6. Provide drainage and cleanup for wash-down procedures.
 - 7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents in accordance with manufacturer's written instructions after removal of surface deposits and debris.

3.8 STARTUP

- A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.9 DUCT SCHEDULE

- A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:
 - 1. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as indicated below.
- B. Supply Ducts:
 - 1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units :
 - a. Pressure Class: Positive 2-inch wg.
 - b. Minimum SMACNA Seal Class: C.
 - c. SMACNA Leakage Class for Rectangular: 16.
 - d. SMACNA Leakage Class for Round and Flat Oval: 8.
- C. Return Ducts:
 - 1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units :
 - a. Pressure Class: Positive or negative 1-inch wg.
 - b. Minimum SMACNA Seal Class: C.
 - c. SMACNA Leakage Class for Rectangular: 16.
 - d. SMACNA Leakage Class for Round and Flat Oval: 8.
- D. Exhaust Ducts:
 - 1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
 - a. Pressure Class: Negative 1-inch wg.
 - b. Minimum SMACNA Seal Class: C if negative pressure, and A if positive pressure.
 - c. SMACNA Leakage Class for Rectangular: 16.
 - d. SMACNA Leakage Class for Round and Flat Oval: 8.
- E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:
 - 1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units :
 - a. Pressure Class: Positive or negative 1-inch wg.
 - b. Minimum SMACNA Seal Class: C.
 - c. SMACNA Leakage Class for Rectangular: 16.
 - d. SMACNA Leakage Class for Round and Flat Oval: 8.
- F. Elbow Configuration:
 - 1. Rectangular Duct - Requirements for Different Velocities: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Velocity 1000 fpm or Lower:
 - 1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
 - 2) Mitered Type RE 4 without vanes.
 - b. Velocity 1000 to 1500 fpm:
 - 1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
 - c. Velocity 1500 fpm or Higher:
 - 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.

- 2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
 2. Rectangular Duct - Requirements for All Velocities: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
 3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
 - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - 1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
 - 2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
 - 3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
 - 4) Radius-to Diameter Ratio: 1.5.
 - b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
 - c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.
- G. Branch Configuration:
 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.
 - b. Rectangular Main to Round Branch: Conical spin in.
 2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
 - a. Velocity 1000 fpm or Lower: 90-degree tap.
 - b. Velocity 1000 to 1500 fpm: Conical tap.
 - c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 233113

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Backdraft and pressure relief dampers.
 - 2. Manual volume dampers.
 - 3. Fire dampers.
 - 4. Flange connectors.
 - 5. Turning vanes.
 - 6. Duct-mounted access doors.
 - 7. Duct accessory hardware.
- B. Related Requirements:
 - 1. Section 233346 "Flexible Ducts" for insulated and non-insulated flexible ducts.
 - 2. Section 233723 "HVAC Gravity Ventilators" for roof-mounted ventilator caps.
 - 3. Section 284621.11 "Addressable Fire-Alarm Systems" for duct-mounted fire and smoke detectors.
 - 4. Section 284621.13 "Conventional Fire-Alarm Systems" for duct-mounted fire and smoke detectors.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. For duct silencers, include pressure drop, dynamic insertion loss, and self-generated noise data. Include breakout noise calculations for high-transmission-loss casings.
- B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail duct accessories' fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
 - a. Special fittings.
 - b. Manual volume damper installations.
 - c. Control-damper installations.
 - d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor-damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
 - e. Duct security bars.
 - f. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, or BIM model, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from installers of the items involved.
- B. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Comply with NFPA 90A and NFPA 90B.
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 BACKDRAFT AND PRESSURE RELIEF DAMPERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. American Warming and Ventilating (AWV); Mestek, Inc.
 - 2. Cesco Products; MESTEK, Inc.
 - 3. Greenheck Fan Corporation.
 - 4. Lloyd Industries, Inc.
 - 5. NCA Manufacturing, Inc.; Metal Industries, Inc.
 - 6. Nailor Industries Inc.
 - 7. Pottorff.
 - 8. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
 - 9. Safe Air - Dowco.
 - 10. United Enertech Corp.

- 11. Vent Products Co., Inc.
- C. Description: Gravity balanced.
- D. Performance:
 - 1. Maximum Air Velocity: 1000 fpm.
 - 2. Maximum System Pressure: 1 inch wg.
 - 3. Leakage:
 - a. Class IA: Leakage shall not exceed 3 cfm/sq. ft. against 1-inch wg differential static pressure.
 - b. Class I: Leakage shall not exceed 4 cfm/sq. ft. against 1-inch wg differential static pressure.
 - c. Class II: Leakage shall not exceed 10 cfm/sq. ft. against 1-inch wg differential static pressure.
 - d. Class III: Leakage shall not exceed 40 cfm/sq. ft. against 1-inch wg differential static pressure.
- E. Construction:
 - 1. Frame:
 - a. Hat shaped.
 - b. 16-gauge- thick, galvanized sheet steel 0.093-inch- thick extruded aluminum, with welded or mechanically attached corners.
 - 2. Blades:
 - a. Multiple single-piece blades.
 - b. Center pivoted, maximum 6-inch width, 16-gauge- thick, 0.050-inch- thick aluminum sheet with sealed edges.
 - 3. Blade Action: Parallel.
- F. Blade Seals: **Extruded vinyl, mechanically locked.**
- G. Blade Axles:
 - 1. Material: Galvanized steel.
 - 2. Diameter: 0.20 inch.
- H. Tie Bars and Brackets: Galvanized steel.
- I. Return Spring: Adjustable tension.
- J. Bearings: Steel ball or synthetic pivot bushings.
- K. Damper Actuator - Electric:
 - 1. Electric - 120 V ac.
 - 2. UL 873 plenum rated.
 - 3. Two position with fail-safe spring return.
 - a. Sufficient motor torque and spring torque to drive damper fully closed with adequate force to achieve required damper seal.
 - b. Minimum 90-degree drive rotation.
 - 4. Clockwise or counterclockwise drive rotation as required for application.
 - 5. Environmental Operating Range:
 - a. Temperature: Minus 40 to plus 130 deg F.

- b. Humidity: 5 to 95 percent relative humidity noncondensing.
- 6. Environmental Enclosure: NEMA 2.
- 7. Actuator to be factory mounted and provided with a single-point wiring connection.
- L. Controllers, Electrical Devices, and Wiring:
 - 1. Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
 - 2. Electrical Connection: 115 V, single phase, 60 Hz.
- M. Accessories:
 - 1. Adjustment device to permit setting for varying differential static pressure.
 - 2. Counterweights and spring-assist kits for vertical airflow installations.
 - 3. Chain pulls.
 - 4. Screen Mounting:
 - a. Front mounted in sleeve.
 - 1) Sleeve Thickness: 20 gauge minimum.
 - 2) Sleeve Length: 6 inches minimum.
 - 5. Screen Material: Galvanized steel.
 - 6. Screen Type: Bird.
 - 7. 90-degree stops.

2.3 MANUAL VOLUME DAMPERS

- A. Standard, Steel, Manual Volume Dampers:
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Air Balance; MESTEK, Inc.
 - b. Aire Technologies, Inc.; DMI Companies.
 - c. American Warming and Ventilating (AWV); Mestek, Inc.
 - d. Arrow United Industries; Mestek, Inc.
 - e. Cesco Products; MESTEK, Inc.
 - f. Greenheck Fan Corporation.
 - g. Lloyd Industries, Inc.
 - h. McGill AirFlow LLC.
 - i. Nailor Industries Inc.
 - j. Pottorff.
 - k. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
 - l. Safe Air - Dowco.
 - m. United Enertech Corp.
 - n. Vent Products Co., Inc.
 - 3. Performance:
 - a. Leakage Rating Class III: Leakage not exceeding 40 cfm/sq. ft. against 1-inch wg differential static pressure.
 - 4. Construction:
 - a. Linkage out of airstream.
 - b. Suitable for horizontal or vertical airflow applications.
 - 5. Frames:

- a. Hat-shaped, 16-gauge- thick, galvanized sheet steel.
 - b. Mitered and welded corners.
 - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
 6. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Galvanized steel; 16 gauge thick.
 7. Blade Axles: Galvanized steel.
 8. Bearings:
 - a. Oil-impregnated bronze.
 - b. Dampers mounted with vertical blades to have thrust bearing at each end of every blade.
 9. Tie Bars and Brackets: Galvanized steel.
 10. Locking device to hold damper blades in a fixed position without vibration.
- B. Standard, Aluminum, Manual Volume Dampers:
1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Warming and Ventilating (AWV); Mestek, Inc.
 - b. Arrow United Industries; Mestek, Inc.
 - c. CESCO Products; MESTEK, Inc.
 - d. Linx Industries; a DMI company (formerly Lindab).
 - e. Lloyd Industries, Inc.
 - f. McGill AirFlow LLC.
 - g. Nailor Industries Inc.
 - h. Pottorff.
 - i. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
 - j. Safe Air - Dowco.
 - k. United Enertech Corp.
 - l. Vent Products Co., Inc.
 3. Performance:
 - a. Leakage Rating Class III: Leakage not exceeding 40 cfm/sq. ft. against 1-inch wg differential static pressure.
 4. Construction:
 - a. Linkage out of airstream.
 - b. Suitable for horizontal or vertical airflow applications.
 5. Frames:
 - a. Hat-shaped, 0.10-inch- thick, aluminum sheet channels.
 - b. Flanges for attaching to walls and flangeless frames for installing in ducts.
 6. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Roll-Formed Aluminum Blades: 0.10-inch- thick aluminum sheet.
 - e. Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.
 7. Blade Axles: Galvanized steel.
 8. Bearings:

- a. Oil-impregnated bronze.
- b. Dampers mounted with vertical blades to have thrust bearing at each end of every blade.
9. Tie Bars and Brackets: Aluminum.
10. Locking device to hold damper blades in a fixed position without vibration.

2.4 FIRE DAMPERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Air Balance; MESTEK, Inc.
 2. Aire Technologies, Inc.; DMI Companies.
 3. Arrow United Industries; Mestek, Inc.
 4. CL WARD & Family Inc.
 5. Cesco Products; MESTEK, Inc.
 6. Greenheck Fan Corporation.
 7. NCA Manufacturing, Inc.; Metal Industries, Inc.
 8. Pottorff.
 9. Prefco.
 10. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
 11. Safe Air - Dowco.
 12. United Enertech Corp.
 13. Vent Products Co., Inc.
- C. Type: Static and dynamic; rated and labeled in accordance with UL 555 by an NRTL.
- D. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000 fpm velocity.
- E. Fire Rating: 3 hours.
- F. Frame: Curtain type with blades inside airstream; fabricated with roll-formed galvanized steel; with mitered and interlocking corners; gauge in accordance with UL listing.
- G. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel; gauge in accordance with UL listing.
- H. Mounting Orientation: Vertical or horizontal as indicated.
- I. Blades: Roll-formed galvanized sheet steel, interlocking. Material gauge is to be in accordance with UL listing.
- J. Horizontal Dampers: Include blade lock and stainless steel closure spring.
- K. Heat-Responsive Device:
 1. Replaceable, 165 deg F rated, fusible links.

2.5 FLANGE CONNECTORS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. CL WARD & Family Inc.
 - 2. Ductmate Industries, Inc; a DMI company.
 - 3. DynAir; a Carlisle Company.
 - 4. Elgen Manufacturing.
 - 5. Ward Industries; a brand of Hart & Cooley, LLC.
- C. Description: Add-on or roll-formed, factory fabricated, slide-on transverse flange connectors, gaskets, and components.
- D. Material: Galvanized steel.
- E. Gauge and Shape: Match connecting ductwork.

2.6 TURNING VANES

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Aero-Dyne Sound Control Co.
 - 2. CL WARD & Family Inc.
 - 3. Ductmate Industries, Inc; a DMI company.
 - 4. Duro Dyne Inc.
 - 5. DynAir; a Carlisle Company.
 - 6. Elgen Manufacturing.
 - 7. Ward Industries; a brand of Hart & Cooley, LLC.
- C. Manufactured Turning Vanes for Metal Ducts: Fabricate curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
 - 1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.
- D. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- E. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
- F. Vane Construction:

1. Single wall.
2. Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.7 DUCT-MOUNTED ACCESS DOORS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Aire Technologies, Inc.; DMI Companies.
 2. Arrow United Industries; Mestek, Inc.
 3. CL WARD & Family Inc.
 4. Cesco Products; MESTEK, Inc.
 5. Ductmate Industries, Inc; a DMI company.
 6. Ductmate Industries, Inc; a DMI company.
 7. Duro Dyne Inc.
 8. Elgen Manufacturing.
 9. Flexmaster U.S.A., Inc.
 10. McGill AirFlow LLC.
 11. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
 12. United Enertech Corp.
 13. Ventfabrics, Inc.
 14. Ward Industries; a brand of Hart & Cooley, LLC.
- C. Duct-Mounted Access Doors: Fabricate access panels in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 7-2 (7-2M), "Duct Access Doors and Panels," and Figure 7-3, "Access Doors - Round Duct."
 1. Door:
 - a. Double wall, rectangular.
 - b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - c. 24-gauge- thick galvanized steel or 0.032-inch thick aluminum door panel.
 - d. Vision panel.
 - e. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
 - f. Fabricate doors airtight and suitable for duct pressure class.
 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 - a. 24-gauge- thick galvanized steel or 0.032-inch- thick aluminum frame.
 3. Number of Hinges and Locks:
 - a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
 - b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.

2.8 DUCT ACCESSORY HARDWARE

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. CL WARD & Family Inc.
2. Ductmate Industries, Inc; a DMI company.
3. Duro Dyne Inc.
4. DynAir; a Carlisle Company.
5. Elgen Manufacturing.
6. Hardcast; Carlisle Construction Materials.
7. United Eneritech Corp.
8. Ventfabrics, Inc.
9. Ward Industries; a brand of Hart & Cooley, LLC.

- C. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.
- D. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

2.9 MATERIALS

- A. Galvanized Sheet Steel: Comply with ASTM A653/A653M.
1. Galvanized Coating Designation: G60.
 2. Exposed-Surface Finish: Mill phosphatized.
- B. Stainless Steel Sheets: Comply with ASTM A480/A480M, Type 304, and having a No. 2 finish for concealed ducts.
- C. Aluminum Sheets: Comply with ASTM B209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, one-side bright finish for exposed ducts.
- D. Extruded Aluminum: Comply with ASTM B221, Alloy 6063, Temper T6.
- E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless steel ducts.
- F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install duct accessories in accordance with applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116 for fibrous-glass ducts.
- B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless steel accessories in stainless steel ducts, and aluminum accessories in aluminum ducts.

- C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- D. Where multiple damper sections are necessary to achieve required dimensions, provide reinforcement to fully support damper assembly when fully closed at full system design static pressure.
- E. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
 - 1. Install steel volume dampers in steel ducts.
 - 2. Install aluminum volume dampers in aluminum ducts.
- F. Set dampers to fully open position before testing, adjusting, and balancing.
- G. Install test holes at fan inlets and outlets and elsewhere as indicated and as needed for testing and balancing.
- H. Install fire dampers in accordance with UL listing.
- I. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - 1. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
 - 2. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
 - 3. Control devices requiring inspection.
 - 4. Elsewhere as indicated.
- J. Install access doors with swing against duct static pressure.
- K. Access Door Sizes:
 - 1. One-Hand or Inspection Access: 8 by 5 inches.
 - 2. Two-Hand Access: 12 by 6 inches.
 - 3. Head and Hand Access: 18 by 10 inches.
 - 4. Head and Shoulders Access: 21 by 14 inches.
 - 5. Body Access: 25 by 14 inches.
 - 6. Body plus Ladder Access: 25 by 17 inches.
- L. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
- M. Install flexible connectors to connect ducts to equipment.
- N. For fans developing static pressures of 5 inches wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- O. Install duct test holes where required for testing and balancing purposes.

- P. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors, and verify that size and location of access doors are adequate to perform required operation.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation, and verify that vanes do not move or rattle.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 233300

SECTION 233713.13 – AIR DIFFUSERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Rectangular and square ceiling diffusers.
- B. Related Requirements:
 - 1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
 - 2. Diffuser Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.
- B. Samples: For each exposed product and for each color and texture specified. Actual size of smallest diffuser indicated.
- C. Samples for Initial Selection: For diffusers with factory-applied color finishes. Actual size of smallest diffuser indicated.
- D. Samples for Verification: For diffusers, in manufacturer's standard sizes to verify color selected. Actual size of smallest diffuser indicated.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Ceiling suspension assembly members.
 - 2. Method of attaching hangers to building structure.
 - 3. Size and location of initial access modules for acoustical tile.
 - 4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
 - 5. Duct access panels.

- B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 RECTANGULAR AND SQUARE CEILING DIFFUSERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. A-J Manufacturing Co., Inc.
 - 2. Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.
 - 3. Carnes Company.
 - 4. Hart & Cooley, LLC.
 - 5. Krueger-HVAC; brand of Johnson Controls International plc, Global Products.
 - 6. METALAIRE, Inc.
 - 7. Nailor Industries Inc.
 - 8. Price Industries Limited.
 - 9. Shoemaker Mfg. Co.
 - 10. Titus; brand of Johnson Controls International plc, Global Products.
 - 11. Tuttle & Bailey; brand of Johnson Controls International plc, Global Products.
- C. Devices shall be specifically designed for variable-air-volume flows.
- D. Material: Steel.
- E. Finish: Baked enamel, white.
- F. Face Size: 24 by 24 inches.
- G. Face Style: Three cone.
- H. Mounting: Surface.
- I. Pattern: Fixed.
- J. Dampers: Radial opposed blade.
- K. Accessories:
 - 1. Equalizing grid.
 - 2. Plaster ring.
 - 3. Safety chain.
 - 4. Wire guard.
 - 5. Sectorizing baffles.
 - 6. Operating rod extension.

2.2 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate diffusers according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas where diffusers are installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install diffusers level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

- A. After installation, adjust diffusers to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713.13

SECTION 238129 - VARIABLE-REFRIGERANT-FLOW HVAC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes complete VRF HVAC system(s) including, but not limited to the following components to make a complete operating system(s) according to requirements indicated:
 - 1. Indoor, concealed, ceiling-mounted units for ducting.
 - 2.
 - 3. Indoor, energy recovery ventilator.
 - 4. Outdoor, air-source, heat-pump units.
 - 5. System controls.
 - 6. System refrigerant and oil.
 - 7. System condensate drain piping.
 - 8. System hydronic piping.
 - 9. System refrigerant piping.
 - 10. Metal hangers and supports.
 - 11. Metal framing systems.
 - 12. Fastener systems.
 - 13. Pipe stands.
 - 14. Equipment stands.
 - 15. Miscellaneous support materials.
 - 16. Piping and tubing insulation.
 - 17. System control cable and raceways.

1.3 DEFINITIONS

- A. Air-Conditioning System Operation: System capable of operation with all zones in cooling only.
- B. Heat-Pump System Operation: System capable of operation with all zones in either heating or cooling, but not with simultaneous heating and cooling zones that transfer heat between zones.
- C. Heat Recovery System Operation: System capable of operation with simultaneous heating and cooling zones that transfer heat between zones.
- D. HRCU: Heat Recovery Control Unit. HRCUs are used in heat recovery VRF HVAC systems to manage and control refrigerant between indoor units to provide simultaneous heating and

cooling zones. "Heat Recovery Control Unit" is the term used by ASHRAE for what different manufacturers term as branch circuit controller, branch selector box, changeover box, flow selector unit, mode change unit, and other such terms.

- E. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
- F. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.
- G. Three-Pipe System Design: One high pressure refrigerant vapor line, one low pressure refrigerant vapor line, and one refrigerant liquid line connect a single outdoor unit or multiple manifold outdoor units in a single system to associated system HRCUs. One liquid line and refrigerant vapor line connect HRCUs to associated indoor units.
- H. Two-Pipe System Design: One refrigerant vapor line and one refrigerant liquid line connect a single outdoor unit or multiple manifold outdoor units in a single system to associated system HRCUs. One refrigerant liquid line and refrigerant vapor line connect HRCUs to associated indoor units. HRCUs used in two pipe systems act as an intermediate heat exchanger and include diverting valves and gas/liquid separators to move high and low pressure refrigerant between indoor units.
- I. VRF: Variable refrigerant flow.

1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for indoor and outdoor units.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 3. Include operating performance at design conditions and at extreme maximum and minimum outdoor ambient conditions.
 - 4. Include description of system controllers, dimensions, features, control interfaces and connections, power requirements, and connections.
 - 5. Include system operating sequence of operation in narrative form for each unique indoor-and outdoor-unit control.
 - 6. Include description of control software features.
 - 7. Include total refrigerant required and a comprehensive breakdown of refrigerant required by each system installed.
 - 8. Include refrigerant type and data sheets showing compliance with requirements indicated.
 - 9. For system design software.

10. Indicate location and type of service access.

B. Shop Drawings: For VRF HVAC systems.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
4. Include diagrams and details of refrigerant piping and tubing showing installation requirements for manufacturer-furnished divided flow fittings.
5. Include diagrams for power, signal, and control wiring.

C. Samples for Initial Selection: For fully and partially exposed indoor units with factory finishes viewable by occupants.

1. Include a Sample for each unique finish with unit identification, detailed description of application, and cross-referenced floor plans showing locations.

D. Delegated-Design Submittals:

1. Include design calculations for selecting vibration isolators and for designing vibration isolation bases.
2. Include design calculations with corresponding diagram of refrigerant piping and tubing sizing for each system installed.
3. Include design calculations with corresponding floor plans indicating that refrigerant concentration limits are within allowable limits of ASHRAE 15 and governing codes.
4. Include calculations showing that system travel distance for refrigerant piping and controls cabling are within horizontal and vertical travel distances set by manufacturer. Provide a comparison table for each system installed.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, sections, and details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural floors, roofs and associated members to which equipment, piping, ductwork, cables, and conduit will be attached.
3. Size and location of initial access modules for acoustical tile.
4. Wall-mounted controllers located in finished space showing relationship to light switches, fire-alarm devices, and other installed devices.
5. Size and location of access doors and panels installed behind walls and inaccessible ceilings for products installed behind walls and requiring access.
6. Items penetrating finished ceiling including the following:

- a. Luminaires.
- b. Air outlets and inlets.
- c. Speakers.
- d. Sprinklers.
- e. Service access panels.

B. Qualification Data:

1. For Installer: Certificate from VRF HVAC system manufacturer certifying that Installer has successfully completed prerequisite training administered by manufacturer for proper installation of systems, including but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.
 - a. Retain copies of Installer certificates on-site and make available on request.
 2. For VRF HVAC system manufacturer.
 3. For VRF HVAC system provider.
- C. Product Test Reports: Where tests are required, for each product, for tests performed by manufacturer and witnessed by a qualified testing agency or a qualified testing agency.
- D. Source quality-control reports.
- E. Field quality-control reports.
- F. Sample Warranties: For manufacturer's warranties.

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For VRF HVAC systems to include in emergency, operation, and maintenance manuals.
- B. Software and Firmware Operational Documentation:
1. Software operating and upgrade manuals.
 2. Program Software Backup: On CD or DVD, USB media, or approved cloud storage platform, complete with data files.
 3. Device address list.
 4. Printout of software application and graphic screens.

1.8 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Filters:
 - a. One set(s) for each unit with replaceable filters.

- b. One set(s) for each unit type and unique size of washable filters.
- 2. Indoor Units: One for each unique size and type installed.
- 3. Controllers for Indoor Units: One for each unique controller type installed.

1.9 QUALITY ASSURANCE

A. Manufacturer Qualifications:

- 1. Nationally recognized manufacturer of VRF HVAC systems and products.
- 2. Shipped VRF HVAC systems with similar requirements to those indicated for a continuous period of five years within time of bid.
- 3. VRF HVAC systems and products that have been successfully tested and in use on at least three completed projects.
- 4. Having complete published catalog literature, installation, and operation and maintenance manuals for all products intended for use.
- 5. Having full-time in-house employees for the following:
 - a. Product research and development.
 - b. Product and application engineering.
 - c. Product manufacturing, testing, and quality control.
 - d. Technical support for system installation training, startup, commissioning, and troubleshooting of installations.
 - e. Owner training.

B. Factory-Authorized Service Representative Qualifications:

- 1. Authorized representative of, and trained by, VRF HVAC system manufacturer.
- 2. Demonstrated past experience with products being installed for period within three consecutive years before time of bid.
- 3. Demonstrated past experience on five projects of similar complexity, scope, and value.
 - a. Each person assigned to Project shall have demonstrated past experience.
- 4. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
- 5. Service and maintenance staff assigned to support Project during warranty period.
- 6. Product parts inventory to support ongoing system operation for a period of not less than five years after Substantial Completion.
- 7. VRF HVAC system manufacturer's backing to take over execution of Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

C. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by VRF HVAC system manufacturer.

- 1. Each employee shall be certified by manufacturer for proper installation of systems, including, but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.

2. Installer certification shall be valid and current for duration of Project.
3. Retain copies of Installer certificates on-site and make available on request.
4. Each person assigned to Project shall have demonstrated past experience.
 - a. Demonstrated past experience with products being installed for period within three consecutive years before time of bid.
 - b. Demonstrated past experience on five projects of similar complexity, scope, and value.

D. Mockups: Build mockups to set quality standards for materials and execution.

1. Build mockups to show a finished installation for each of the following applications:
 - a. For each different indoor unit type with exposed surfaces viewable by occupants.
2. Mockups shall be operational.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

E. ISO Compliance: System equipment and components furnished by VRF HVAC system manufacturer shall be manufactured in an ISO 9001 and ISO 14001 facility.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store products in a clean and dry place.
- B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.
- C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.
- D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.
 1. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.
 2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remove coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.
- E. Replace installed products damaged during construction.

1.11 WARRANTY

- A. **Manufacturer's Warranty:** Manufacturer agrees to repair or replace equipment and components that fail(s) in materials or workmanship within specified warranty period.
1. Failures include, but are not limited to, the following:
 - a. Structural failures.
 - b. Faulty operation.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal weathering and use.
 2. Warranty Period:
 - a. For Compressor: Five year(s) from date of Substantial Completion.
 - b. For Parts, Including Controls: Five year(s) from date of Substantial Completion.
 - c. For Labor: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. **Basis-of-Design Product:** Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
- B. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
1. Carrier Global Corporation.
 2. Daikin Applied.
 3. Fujitec America, Inc.
 4. Johnson Controls, Inc.
 5. LG Electronics USA, Inc.; LG Electronics Inc.
 6. Mitsubishi Electric & Electronics USA, Inc.
 7. Panasonic Corporation of North America.
 8. RectorSeal HVAC; a CSW Industrials Company.
 9. Samsung HVAC.
 10. Trane Inc.
- C. **Source Limitations:** Obtain products from single source from single manufacturer including, but not limited to, the following:
1. Indoor and outdoor units, including accessories.
 2. Controls and software.
 3. HRCUs.
 4. Refrigerant isolation valves.
 5. Specialty refrigerant pipe fittings.

2.2 SYSTEM DESCRIPTION

- A. Direct-expansion (DX) VRF HVAC system(s) with variable capacity in response to varying cooling and heating loads. System shall consist of multiple indoor units, outdoor unit(s), piping, controls, and electrical power to make complete operating system(s) complying with requirements indicated.
 - 1. Two-pipe system design.
 - 2. System(s) operation, heat pump as indicated on Drawings.
 - 3. Each system with one refrigerant circuit shared by all indoor units connected to system.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. AHRI Compliance: System and equipment performance certified according to AHRI 1230.
- D. ASHRAE Compliance:
 - 1. ASHRAE 15: For safety code for mechanical refrigeration.
 - 2. ASHRAE 62.1: For indoor air quality.
 - 3. ASHRAE 135: For control network protocol with remote communication.
 - 4. ASHRAE/IES 90.1 Compliance: For system and component energy efficiency.
- E. UL Compliance: Comply with UL 1995.

2.3 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional specialist, as defined in Section 014000 "Quality Requirements," to design complete and operational VRF HVAC system(s) complying with requirements indicated.
 - 1. Provide system refrigerant calculations.
 - a. Refrigerant concentration limits shall be within allowable limits of ASHRAE 15 and governing codes.
 - b. Indicate compliance with manufacturer's maximum vertical and horizontal travel distances. Prepare a comparison table for each system showing calculated distances compared to manufacturer's maximum allowed distances.
 - 2. Include a mechanical ventilation system and gas detection system as required to comply with ASHRAE 15 and governing codes.
 - 3. System Refrigerant Piping and Tubing:
 - a. Arrangement: Arrange piping to interconnect indoor units and outdoor unit(s) in compliance with manufacturer requirements and requirements indicated.
 - b. Routing: Conceal piping above ceilings and behind walls to maximum extent possible.

- c. Sizing: Size piping system, using a software program acceptable to manufacturer, to provide performance requirements indicated. Consider requirements to accommodate future change requirements.
 - 4. System Controls:
 - a. Network arrangement.
 - b. Network interface with other building systems.
 - c. Product selection.
 - d. Sizing.
- B. Service Access:
 - 1. Provide and document service access requirements.
 - 2. Locate equipment, system isolation valves, and other system components that require service and inspection in easily accessible locations. Avoid locations that are difficult to access if possible.
 - 3. Where serviceable components are installed behind walls and above inaccessible ceilings, provide finished assembly with access doors or panels to gain access. Properly size the openings to allow for service, removal, and replacement.
 - 4. If less than full and unrestricted access is provided, locate components within an 18-inch reach of the finished assembly.
 - 5. Where ladder access is required to service elevated components, provide an installation that provides for sufficient access within ladder manufacturer's written instructions for use.
 - 6. Comply with OSHA regulations.
- C. System Design and Installation Requirements:
 - 1. Design and install systems indicated according to manufacturer's recommendations and written instructions.
 - 2. Where manufacturer's requirements differ from requirements indicated, contact Architect for direction. The most stringent requirements should apply unless otherwise directed in writing by Architect.
- D. System Adaptability to Future Changes: Arrange and size system refrigerant piping to accommodate future changes to system without having to resize and replace existing refrigerant piping.
 - 1. Future changes to system(s) indicated on Drawings.
 - 2. Each branch circuit shall accommodate addition of **one** indoor unit(s) with unit capacity equal to **largest** indoor unit connected to the branch circuit.
 - 3. Each branch circuit shall accommodate deletion of **one** indoor unit(s) with unit capacity equal to **largest** indoor unit connected to the branch circuit.
- E. Isolation of Equipment: Provide isolation valves to isolate each indoor unit and outdoor unit for service, removal, and replacement without interrupting system operation.
- F. System Capacity Ratio: The sum of connected capacity of all indoor units shall be within the following range of outdoor-unit rated capacity:

1. Not less than **50** percent.
 2. Not more than **130** percent.
 3. Range acceptable to manufacturer.
- G. System Turndown: Stable operation down to 20 percent of outdoor-unit capacity.
- H. System Auto Refrigerant Charge: Each system shall have an automatic refrigerant charge function to ensure the proper amount of refrigerant is installed in system.
- I. Outdoor Conditions:
1. Suitable for outdoor ambient conditions encountered.
 - a. Design equipment and supports to withstand wind loads of governing code .
 - b. Design equipment and supports to withstand snow and ice loads of governing code .
 - c. Provide corrosion-resistant coating for components and supports where located in coastal or industrial climates that are known to be harmful to materials and finishes.
 2. Maximum System Operating Outdoor Temperature: See Drawings.
 3. Minimum System Operating Outdoor Temperature: See Drawings.
- J. Seismic Performance: VRF HVAC system(s) shall withstand the effects of earthquake motions determined according to .
1. The term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified."
 2. Component Importance Factor: 1.5.
- K. Sound Performance: Sound levels generated by operating HVAC equipment shall be within requirements indicated.
1. Indoor: See Drawings.
 2. Outdoor: See Drawings.
- L. Thermal Movements: Allow for controlled thermal movements from ambient, surface, and system temperature changes.
- M. Capacities and Characteristics: As indicated on Drawings.
- 2.4 INDOOR, CONCEALED, CEILING-MOUNTED UNITS FOR DUCTING
- A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.
- B. Cabinet:
1. Material: Galvanized or painted steel.

2. Insulation: Manufacturer's standard internal insulation to provide thermal resistance and prevent condensation.
3. Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.
4. Mounting: Manufacturer-designed provisions for field installation.
5. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:

1. Coil Casing: Aluminum, galvanized, or stainless steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
5. Unit Internal Tubing: Copper tubing with brazed joints.
6. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.
9. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.
3. Field Piping Connection: Non-ferrous material.

E. Fan and Motor Assembly:

1. Fan(s):
 - a. Direct-drive arrangement.
 - b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
 - c. Fabricated from non-ferrous components or ferrous components with corrosion-resistant finish.
 - d. Wheels statically and dynamically balanced.
2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:

1. Access: Bottom, side, or rear to accommodate field installation without removing ductwork and to accommodate filter replacement without need for tools.

2. Efficiency: ASHRAE 52.2, MERV 7.
3. Media:
 - a. Replaceable: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.
 - b. Washable: Manufacturer's standard filter with antimicrobial treatment.

G. Unit Accessories:

1. Outdoor Air Ventilation Kit: Connection, motorized damper, and control sized to allow sequence of operation indicated on Drawings.
2. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.

H. Unit Controls:

1. Enclosure: Metal, suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:
 - a. Unit inlet air temperature.
 - b. Coil entering refrigerant temperature.
 - c. Coil leaving refrigerant temperature.
4. Field-Customizable I/O Capability:
 - a. Analog Inputs: Two for use in customizable control strategies.
 - b. Digital Inputs: Two for use in customizable control strategies.
 - c. Digital Outputs: Two for use in customizable control strategies.
5. Features and Functions:
 - a. Self-diagnostics.
 - b. Time delay.
 - c. Auto-restart.
 - d. External static pressure control.
 - e. Auto operation mode.
 - f. Manual operation mode.
 - g. Filter service notification.
 - h. Power consumption display.
 - i. Drain assembly high water level safety shutdown and notification.
 - j. Run test switch.
6. Communication: Network communication with other indoor and outdoor units.
7. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
8. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

I. Unit Electrical:

1. Enclosure: Metal, suitable for indoor locations.
2. Field Connection: Single point connection to power unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in raceways.

2.5 INDOOR, ENERGY RECOVERY VENTILATOR

- A. Description: Factory-assembled complete unit with components, wiring, and controls required for mating to ductwork, power, and controls field connections.
- B. Cabinet:
 1. Material: Galvanized steel.
 2. Insulation: Manufacturer's standard internal insulation.
 3. Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.
 4. Mounting: Manufacturer-designed provisions for field installation.
 5. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
- C. Damper Assemblies:
 1. Outdoor Air Intake and Exhaust Air Discharge:
 - a. Low-leakage damper with spring return electric actuator to fail closed on loss of power.
 - b. Damper controlled by unit to open when unit is operating and close when unit off.
 2. Energy Recovery Heat-Exchanger Bypass:
 - a. Low leakage damper with electric actuator with integral controls to bypass outdoor air around the energy recovery heat exchanger during times of favorable weather, and there is no energy-saving benefit to circulate air across the energy recovery heat exchanger.
- D. Fan and Motor Assemblies: Separate fan and motor assemblies for supply and exhaust airstreams with control for equal airflow.
 1. Fan(s):
 - a. Direct-drive arrangement.
 - b. Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
 - c. Wheels statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
 3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
 4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
 5. Vibration Control: Integral isolation to dampen vibration transmission.
- E. Filter Assemblies: Separate filter assemblies for outdoor air and exhaust airstreams entering energy recovery heat exchanger.
1. Access: To accommodate filter replacement without the need for tools.
 2. Efficiency: ASHRAE 52.2, MERV 7.
 3. Replaceable Media: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.
- F. Energy Recovery Heat Exchanger:
1. Total (sensible and latent) energy exchange between outdoor air and exhaust airstreams with performance indicated on Drawings.
 2. Fixed element with no moving parts.
 3. AHRI 1060 certified and bearing the AHRI label.
- G. Unit Accessories:
1. Electric Duct Preheater:
 - a. Heater operation interlocked with energy recovery ventilator unit.
 - b. Heater with integral controls to control outdoor air temperature entering energy recovery ventilator unit to a temperature set-point determined by energy recovery ventilator unit manufacturer.
 - c. Listed and labeled.
- H. Unit Controls:
1. Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
 2. Factory-Installed Controller: Configurable digital control.
 3. Factory-Installed Sensors:
 - a. Unit entering outdoor air temperature.
 - b. Unit leaving supply air temperature.
 - c. Unit entering exhaust air temperature.
 - d. Unit leaving exhaust air temperature.
 - e. Unit entering outdoor air relative humidity.
 - f. Unit leaving supply air relative humidity.
 - g. Unit entering exhaust air relative humidity.
 - h. Unit leaving exhaust air relative humidity.
 - i. **<Insert sensor>**.
 4. Field-Customizable I/O Capability:
 - a. Analog Inputs: Two for use in customizable control strategies.

- b. Digital Inputs: Two for use in customizable control strategies.
- c. Digital Outputs: Two for use in customizable control strategies.
- 5. Features and Functions: Self-diagnostics, time delay, auto-restart.
- 6. Communication: Network communication with other indoor units and outdoor unit(s).
- 7. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
- 8. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

I. Unit Electrical:

- 1. Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
- 2. Field Connection: Single point connection to power entire unit and integral controls.
- 3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
- 4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
- 5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
- 6. Raceways: Enclose line voltage wiring in raceways to comply with NFPA 70.

2.6 OUTDOOR, AIR-SOURCE HEAT-PUMP UNITS

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

- 1. Specially designed for use in systems with either all heating or all cooling demands, but not for use in systems with simultaneous heating and cooling.
- 2. Systems shall consist of one unit, or multiple unit modules that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.
- 3. All units installed shall be from the same product development generation.

B. Cabinet:

- 1. Galvanized steel and coated with a corrosion-resistant finish.
 - a. Coating with documented salt spray test performance of 1000 hours according ASTM B117 surface scratch test (SST) procedure.
- 2. Mounting: Manufacturer-designed provisions for field installation.
- 3. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. Compressor and Motor Assembly:

- 1. One or more positive-displacement, direct-drive and hermetically sealed scroll compressor(s) with inverter drive and turndown to 15 percent of rated capacity.

2. Protection: Integral protection against the following:
 - a. High refrigerant pressure.
 - b. Low oil level.
 - c. High oil temperature.
 - d. Thermal and overload.
 - e. Voltage fluctuations.
 - f. Phase failure and phase reversal.
 - g. Short cycling.
3. Speed Control: Variable to automatically maintain refrigerant suction and condensing pressures while varying refrigerant flow to satisfy system cooling and heating loads.
4. Vibration Control: Integral isolation to dampen vibration transmission.
5. Oil management system to ensure safe and proper lubrication over entire operating range.
6. Crankcase heaters with integral control to maintain safe operating temperature.
7. Fusible plug.

D. Condenser Coil Assembly:

1. Plate Fin Coils:
 - a. Casing: Aluminum, galvanized, or stainless steel.
 - b. Fins: Aluminum or copper, mechanically bonded to tubes, with arrangement required by performance.
 - c. Tubes: Copper, of diameter and thickness required by performance.
2. Aluminum Microchannel Coils:
 - a. Series of flat tubes containing a series of multiple, parallel-flow microchannels layered between refrigerant header manifolds.
 - b. Single- or multiple-pass arrangement.
 - c. Construct fins, tubes, and header manifolds of aluminum alloy.
3. Coating: Corrosion resistant.
4. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.

E. Condenser Fan and Motor Assembly:

1. Fan(s): Propeller type.
 - a. Direct-drive arrangement.
 - b. Fabricated from non-ferrous components or ferrous components with corrosion protection finish to match performance indicated for condenser coil.
 - c. Statically and dynamically balanced.
2. Fan Guards: Removable safety guards complying with OSHA regulations. If using metal materials, coat with corrosion-resistant coating to match performance indicated for condenser coil.

3. Motor(s): Brushless dc or electronically commutated with permanently lubricated bearings and rated for outdoor duty.
 4. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
 5. Speed Settings and Control: Variable speed with a speed range of least 75 percent.
 6. Vibration Control: Integral isolation to dampen vibration transmission.
- F. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.
- G. Unit Controls:
1. Enclosure: Manufacturer's standard, and suitable for unprotected outdoor locations.
 2. Factory-Installed Controller: Configurable digital control.
 3. Factory-Installed Sensors:
 - a. Refrigerant suction temperature.
 - b. Refrigerant discharge temperature.
 - c. Outdoor air temperature.
 - d. Refrigerant high pressure.
 - e. Refrigerant low pressure.
 - f. Oil level.
 4. Features and Functions: Self-diagnostics, time delay, auto-restart, fuse protection, auto operation mode, night setback control, equalize run time between multiple same components.
 5. Communication: Network communication with indoor units and other outdoor unit(s).
 6. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 7. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
- H. Unit Electrical:
1. Enclosure: Metal, similar to enclosure, and suitable for unprotected outdoor locations.
 2. Field Connection: Single point connection to power entire unit and integral controls.
 3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
 4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
 5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 6. Raceways: Enclose line voltage wiring in raceways to comply with NFPA 70.
- I. Unit Hardware: Zinc-plated steel, or stainless steel. Coat exposed surfaces with additional corrosion-resistant coating if required to prevent corrosion when exposed to salt spray test for 1000 hours according to ASTM B117.
- J. Unit Piping:
1. Unit Tubing: Copper tubing with brazed joints.

2. Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
3. Field Piping Connections: Manufacturer's standard.
4. Factory Charge: Dehydrated air or nitrogen.
5. Testing: Factory pressure tested and verified to be without leaks.

2.7 SYSTEM CONTROLS

A. General Requirements:

1. Network: Indoor units and outdoor units shall include integral controls and connect through a TIA-485A or manufacturer-selected control network.
2. Network Communication Protocol: Manufacturer proprietary or open control communication between interconnected units.
3. Integration with Building Automation System: ASHRAE 135, BACnet IP and certified by BACnet Testing Lab (BTL), including the following:
 - a. Ethernet connection via RJ-45 connectors and port with transmission at 100 Mbps or higher.
 - b. Integration devices shall be connected to local uninterruptible power supply unit(s) to provide at least 5 minutes of battery backup operation after a power loss.
 - c. Integration shall include **control**.
4. Operator Interface:
 - a. Operators shall interface with system and unit controls through the following:
 - 1) Operator interfaces integral to controllers.
 - 2) Owner-furnished PC connected to central controller(s).
 - 3) Web interface through web browser software.
 - 4) Integration with Building Automation System.
 - b. Users shall be capable of interface with controllers for indoor units control to extent privileges are enabled. Control features available to users shall include the following:
 - 1) On/off control.
 - 2) Temperature set-point adjustment.

B. VRF HVAC System Operator Software for PC:

1. Software offered by VRF HVAC system manufacturer shall provide system operators with ability to monitor and control VRF HVAC system(s) from a single dedicated Owner-furnished PC.
2. Software shall provide operator with a graphic user interface to allow monitoring and control of multiple central controllers from a single device location through point-and-click mouse exchange.
3. Plan views shall show building plans with location of indoor units and identification superimposed on plans.

4. Controls operation mode of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Operation modes available through central controller shall match those operation modes of controllers for indoor units.
5. Schedules operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Schedules daily, weekly, and annual events.
6. Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
7. Optimized start feature to start indoor units before scheduled time to reach temperature set-point at scheduled time based on operating history.
8. Night setback feature to operate indoor units at energy-conserving heating and cooling temperature set-points during unoccupied periods.
9. Supports Multiple Languages: English.
10. Supports Imperial and Metric Temperature Units: Fahrenheit .
11. Displays service notifications and error codes.
12. Monitors and displays up to 3000 item error history and 10000 item operation history for regular reporting and further archiving.
13. Monitors and displays cumulative operating time of indoor units.
14. Able to disable and enable operation of individual controllers for indoor units.
15. Information displayed on individual controllers shall also be available for display.
16. Information displayed for outdoor units, including refrigerant high and low pressures percent capacity.

C. Central Controllers:

1. Centralized control for all indoor and outdoor units from a single central controller location.
 - a. Include multiple interconnected controllers as required.
2. Controls operation mode of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Operation modes available through central controller shall match those operation modes of controllers for indoor units.
3. Schedule operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
 - a. Sets schedule for daily, weekly, and annual events.
 - b. Schedule options available through central controller shall at least include the schedule options of controllers for indoor units.
4. Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
5. Optimized start feature to start indoor units before scheduled time to reach temperature set-point at scheduled time based on operating history.
6. Night setback feature to operate indoor units at energy-conserving heating and cooling temperature set-points during unoccupied periods.
7. Service diagnostics tool.
8. Able to disable and enable operation of individual controllers for indoor units.
9. Information displayed on individual controllers shall also be available for display through central controller.

10. Information displayed for outdoor units, including refrigerant high and low pressures percent capacity.
11. Multiple RJ-45 ports for direct connection to a local PC and an Ethernet network switch.
12. Operator interface through a backlit, high-resolution color display touch panel.

D. Wired Controllers for Indoor Units:

1. Single controller capable of controlling multiple indoor units as group.
2. Auto Timeout Touch Screen LCD: Timeout duration shall be adjustable.
3. Multiple Language: English.
4. Temperature Units: Fahrenheit.
5. On/Off: Turns indoor unit on or off.
6. Hold: Hold operation settings until hold is released.
7. Operation Mode: Cool, Heat, Auto, Dehumidification, Fan Only, and Setback.
8. Temperature Display: 1-degree increments.
9. Temperature Set-Point: Separate set points for Cooling, Heating, and Setback. Adjustable in 1-degree increments between 68 and 75 Fahrenheit.
10. Relative Humidity Display: 1 percent increments.
11. Fan Speed Setting: Select between available options furnished with the unit.
12. Airflow Direction Setting: If applicable to unit, select between available options furnished with the unit.
13. Seven-day programmable operating schedule with up to five events per day. Operations shall include On/Off, Operation Mode, and Temperature Set-Point.
14. Auto Off Timer: Operates unit for an adjustable time duration and then turns unit off.
15. Occupancy detection.
16. Service Notification Display: "Filter" .
17. Service Run Tests: Limit use by service personnel to troubleshoot operation.
18. Error Code Notification Display: Used by service personnel to troubleshoot abnormal operation and equipment failure.
19. User and Service Passwords: Capable of preventing adjustments by unauthorized users.
20. Setting stored in nonvolatile memory to ensure that settings are not lost if power is lost. Battery backup for date and time only.
21. Low-voltage power required for controller shall be powered through non-polar connections to indoor unit.

2.8 SYSTEM REFRIGERANT AND OIL

A. Refrigerant:

1. As required by VRF HVAC system manufacturer for system to comply with performance requirements indicated.
2. ASHRAE 34, Class A1 refrigerant classification.
3. R-410a.

B. Oil:

1. As required by VRF HVAC system manufacturer and to comply with performance requirements indicated.

2.9 SYSTEM CONDENSATE DRAIN PIPING

- A. If more than one material is listed, material selection is Contractor's option.
- B. Copper Tubing:
 - 1. Drawn-Temper Tubing: According to ASTM B88, Type L or Type DWV according to ASTM B306.
 - 2. Wrought-Copper Fittings: ASME B16.22.
 - 3. Wrought-Copper Unions: ASME B16.22.
 - 4. Solder Filler Metals: ASTM B32, lead-free alloys, and water-flushable flux according to ASTM B813.
- C. CPVC plastic pipe according to ASTM F441/F441M, Schedule 40, with socket-type pipe fittings according to ASTM F438 and solvent cement according to ASTM F493.
- D. PVC plastic pipe according to ASTM D1785, Schedule 40, with socket-type pipe fittings according to ASTM D2466 and solvent cement according to ASTM D2564, primer according to ASTM F656.

2.10 SYSTEM REFRIGERANT PIPING

- A. Comply with requirements in Section 232300 "Refrigerant Piping" for system piping requirements.
- B. Refrigerant Piping:
 - 1. Copper Tube: ASTM B280, Type ACR.
 - 2. Wrought-Copper Fittings: ASME B16.22.
 - 3. Brazing Filler Metals: AWS A5.8/A5.8M.
- C. Refrigerant Tubing Kits:
 - 1. Furnished by VRF HVAC system manufacturer.
 - 2. Factory-rolled and -bundled, soft-copper tubing with tubing termination fittings at each end.
 - 3. Standard one-piece length for connecting to indoor units.
 - 4. Pre-insulated with flexible elastomeric insulation of thickness to comply with governing energy code and sufficient to eliminate condensation.
 - 5. Factory Charge: Dehydrated air or nitrogen.
- D. Divided-Flow Specialty Fittings: Where required by VRF HVAC system manufacturer for proper system operation, VRF HVAC system manufacturer shall furnish specialty fittings with identification and instructions for proper installation by Installer.
- E. Refrigerant Isolation Ball Valves:

1. Description: Uni-body full port design, rated for maximum system temperature and pressure, and factory tested under pressure to ensure tight shutoff. Designed for valve operation without removing seal cap.
2. Seals: Compatible with system refrigerant and oil. Seal service life of at least 20 years.
3. Valve Connections: Flare or sweat depending on size.

2.11 METAL HANGERS AND SUPPORTS

A. Copper Tube Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized or copper-coated steel.

B. Plastic Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, galvanized-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel .

2.12 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Business.
 - b. Cooper B-line; brand of Eaton, Electrical Sector.
 - c. Flex-Strut Inc.
 - d. G-Strut.
 - e. Haydon Corporation.
 - f. MIRO Industries.
 - g. Unistrut; Atkore International.
 - h. Wesanco, Inc.
3. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
4. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
5. Channels: Continuous slotted carbon-steel channel with intumed lips.
6. Channel Width: Selected for applicable load criteria.
7. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.

8. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel for use indoors and of stainless steel for use outdoors.
9. Metallic Coating for Use Indoors: No coating.
10. Plastic Coating for Use Outdoors: PVC.

2.13 FASTENER SYSTEMS

- A. Powder-Actuated Fasteners: Threaded, zinc-coated steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- B. Mechanical-Expansion Anchors: Insert-wedge-type anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
 1. Indoor Applications: Zinc-coated or stainless steel.
 2. Outdoor Applications: Stainless steel.

2.14 OUTDOOR EQUIPMENT STANDS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. MIRO Industries.
 2. RectorSeal HVAC; a CSW Industrials Company.
 3. Rooftop Support Systems; Eberl Iron Works, Inc.
- C. Description: Individual foot supports with elevated adjustable channel cross bars and clamps/fasteners/bolts for ground or roof-supported outdoor equipment components, without roof membrane penetration, in a prefabricated system that can be modularly assembled on-site.
- D. Foot Material: Rubber or polypropylene.
- E. Rails Material: Hot-dip galvanized carbon steel.
- F. Wind/Sliding Load Resistance: Up to 100 mph minimum.

2.15 MISCELLANEOUS SUPPORT MATERIALS

- A. Grout: ASTM C1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 1. Properties: Nonstaining, noncorrosive, and nongaseous.

2. Design Mix: 5000-psi, 28-day compressive strength.

B. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; galvanized.

C. Threaded Rods: Continuously threaded. Zinc-plated steel or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar material as rods.

2.16 PIPING AND TUBING INSULATION

A. Comply with requirements in Section 230719 "HVAC Piping Insulation" for system piping insulation requirements.

B. Condensate Drain Piping and Tubing Insulation and Jacket Requirements:

1. Flexible Elastomeric Insulation:

- a. Closed-cell, sponge- or expanded-rubber materials, complying with ASTM C534, Type I for tubular materials.
- b. Indoors: 1/2 inch thick.
- c. Outdoors: 3/4 inch thick.

2. Field-Applied Jacket:

- a. Concealed: None required.
- b. Indoors, Exposed to View: None required.
- c. Outdoors, Exposed to View: Aluminum, smooth, 0.020 inch thick.

C. Refrigerant Tubing Insulation and Jacket Requirements:

1. Flexible Elastomeric Insulation:

- a. Closed-cell, sponge- or expanded-rubber materials, complying with ASTM C534, Type I for tubular materials.
- b. Indoors: 1 inch thick.
- c. Outdoors: 1 inch thick.

2. Field-Applied Jacket:

- a. Concealed: None required.
- b. Indoors, Exposed to View: None required.
- c. Outdoors, Exposed to View: Aluminum, smooth, 0.020 inch thick.

D. Flexible Elastomeric Insulation Adhesive: Comply with MIL-A-24179A, Type II, Class I.

E. PVC Jacket Adhesive: Compatible with PVC jacket.

F. Metal Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.

2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: Aluminum.

2.17 SYSTEM CONTROL CABLE

A. Cable Rating: Listed and labeled for application according to NFPA 70.

1. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262, by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.
 - a. Flame Travel Distance: 60 inches or less.
 - b. Peak Optical Smoke Density: 0.5 or less.
 - c. Average Optical Smoke Density: 0.15 or less.
2. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.
3. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

B. Low-Voltage Control Cabling:

1. Paired Cable: NFPA 70, Type CMG.
 - a. One pair, twisted, No. 16 AWG, stranded (19x29) or No. 18 AWG, stranded (19x30) tinned-copper conductors as required by VRF HVAC system manufacturer.
 - b. PVC insulation.
 - c. Braided or foil shielded.
 - d. PVC jacket.
 - e. Flame Resistance: Comply with UL 1685.
2. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
 - a. One pair, twisted, No. 16 AWG, stranded (19x29) or No. 18 AWG, stranded (19x30) tinned-copper conductors as required by VRF HVAC system manufacturer.
 - b. PVC insulation.
 - c. Braided or foil shielded.
 - d. PVC jacket.
 - e. NFPA 262 includes the standard flame-resistance test criteria in common use for cables and conductors.
 - f. Flame Resistance: Comply with NFPA 262.

C. TIA-485A Network Cabling:

1. Standard Cable: NFPA 70, Type CMG.

- a. Paired, [**one pair**] [**two pairs**], twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
 - b. PVC insulation.
 - c. Unshielded.
 - d. PVC jacket.
 - e. Flame Resistance: Comply with UL 1685.
2. Plenum-Rated Cable: NFPA 70, Type CMP.
- a. Paired, one pair, No. 22 AWG, stranded (7x30) tinned-copper conductors.
 - b. Fluorinated ethylene propylene insulation.
 - c. Unshielded.
 - d. Fluorinated ethylene propylene jacket.
 - e. NFPA 262 includes the standard flame-resistance test criteria in common use for cables and conductors.
 - f. Flame Resistance: NFPA 262.

D. Ethernet Network Cabling: TIA-568-C.2 Category 6 cable with RJ-45 connectors.

1. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of category cable indicated.
2. Conductors: 100-ohm, 23 AWG solid copper.
3. Shielding: Unshielded twisted pairs (UTP).
4. Cable Rating: By application.
5. Jacket: White thermoplastic.

E. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for control wiring and cable raceways.

2.18 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B209.

E. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.

F. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a 3000-hour salt-spray test according to ASTM B117.

1. Standards:
 - a. ASTM B117 for salt spray.
 - b. ASTM D2794 for minimum impact resistance of 100 in-lb.
 - c. ASTM B3359 for cross-hatch adhesion of 5B.
2. Application: Immersion.
3. Thickness: 1 mil.
4. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.19 SOURCE QUALITY CONTROL

- A. Factory Tests: Test and inspect factory-assembled equipment.
- B. Equipment will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports for historical record. Submit reports only if requested.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine products before installation. Reject products that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for piping and tubing to verify actual locations of connections before equipment installation.
- D. Examine roughing-in for ductwork to verify actual locations of connections before equipment installation.
- E. Examine roughing-in for wiring and conduit to verify actual locations of connections before equipment installation.
- F. Examine walls, floors, roofs, and outdoor pads for suitable conditions where equipment will be installed.
- G. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- H. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EQUIPMENT INSTALLATION, GENERAL

- A. Clearance:
 - 1. Maintain manufacturer's recommended clearances for service and maintenance.
 - 2. Maintain clearances required by governing code.
- B. Loose Components: Install components, devices, and accessories furnished by manufacturer, with equipment, that are not factory mounted.
 - 1. Loose components shall be installed by manufacturer's service representative or system Installer under supervision of manufacturer's service representative.
- C. Equipment Restraint Installation: Install equipment with seismic-restraint device. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

3.3 INSTALLATION OF INDOOR UNITS

- A. Install units to be level and plumb while providing a neat and finished appearance.
- B. Unless otherwise required by VRF HVAC system manufacturer, support ceiling-mounted units from structure above using threaded rods; minimum rod size of 3/8 inch.
- C. Adjust supports of exposed and recessed units to draw units tight to adjoining surfaces.
- D. Protect finished surfaces of ceilings, floors, and walls that come in direct contact with units. Refinish or replaced damaged areas after units are installed.
- E. In rooms with ceilings, conceal piping and tubing, controls, and electrical power serving units above ceilings.
- F. In rooms without ceiling, arrange piping and tubing, controls, and electrical power serving units to provide a neat and finished appearance.
- G. Provide lateral bracing if needed to limit movement of suspended units to not more than 0.25 inch.
- H. For floor- and wall-mounted units that are exposed, conceal piping and tubing, controls, and electrical power serving units within walls.
- I. Floor-mounted units located in mechanical rooms.
- J. Install floor-mounted units on support structure indicated on Drawings.
- K. Install floor-mounted units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
- L. Attachment: Install hardware for proper attachment to supported equipment.

- M. Grouting: Place grout under equipment supports and make bearing surface smooth.

3.4 INSTALLATION OF OUTDOOR UNITS

- A. Install units to be level and plumb while providing a neat and finished appearance.
- B. Install outdoor units on support structures indicated on Drawings.
- C. Pad-Mounted Installations: Install outdoor units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 1. Attachment: Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 2. Grouting: Place grout under equipment supports and make bearing surface smooth.
- D. Roof-Mounted Installations: Install outdoor units on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, stainless-steel fasteners.

3.5 GENERAL REQUIREMENTS FOR PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping and tubing systems. Install piping and tubing as indicated unless deviations to layout are approved on coordination drawings.
- B. Install piping and tubing in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping and tubing at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping and tubing above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping and tubing to permit valve servicing.
- F. Install piping and tubing at indicated slopes.
- G. Install piping and tubing free of sags.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping and tubing to allow application of insulation.
- J. Install groups of pipes and tubing parallel to each other, spaced to permit applying insulation with service access between insulated piping and tubing.

- K. Install sleeves for piping and tubing penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- L. Install escutcheons for piping and tubing penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.6 INSTALLATION OF SYSTEM CONDENSATE DRAIN PIPING

A. General Requirements for Drain Piping and Tubing:

- 1. Install a union in piping at each threaded unit connection.
- 2. Install an adjustable stainless-steel hose clamp with adjustable gear operator on unit hose connections. Tighten clamp to provide a leak-free installation.
- 3. If required for unit installation, provide a trap assembly in drain piping to prevent air circulated through unit from passing through drain piping. Comply with more stringent of the following:
 - a. Details indicated on Drawings.
 - b. Manufacturer's requirements.
 - c. Governing codes.
 - d. In the absence of requirements, comply with requirements of ASHRAE handbooks.
- 4. Extend drain piping from units with drain connections to drain receptors as indicated on Drawings. If not indicated on Drawings, terminate drain connection at nearest accessible location that is not exposed to view by occupants.
- 5. Provide each 90-degree change in direction with a Y- or T-fitting. Install a threaded plug connection in the dormant side of fitting or future use as a service cleanout.

B. Gravity Drains:

- 1. Slope piping from unit connection toward drain termination at a constant slope of not less than one percent.

C. Pumped Drains:

- 1. If unit condensate pump or lift mechanism is not included with an integral check valve, install a full-size check valve in each branch pipe near unit connection to prevent backflow into unit.

3.7 INSTALLATION OF REFRIGERANT PIPING

A. Refrigerant Tubing Kits:

- 1. Unroll and straighten tubing to suit installation. Deviations in straightness of exposed tubing shall be unnoticeable to observer.

2. Support tubing using hangers and supports indicated at intervals not to exceed 5 feet. Minimum rod size, 1/4 inch.
 3. Prepare tubing ends and make mating connections to provide a pressure tight and leak-free installation.
- B. Install refrigerant piping according to ASHRAE 15 and governing codes.
- C. Select system components with pressure rating equal to or greater than system operating pressure.
- D. Install piping as short and direct as possible, with a minimum number of joints and fittings.
- E. Arrange piping to allow inspection and service of equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 083113 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.
- F. Install refrigerant piping and tubing in protective conduit where installed belowground.
- G. Install refrigerant piping and tubing in rigid or flexible conduit in locations where exposed to mechanical damage.
- H. Unless otherwise required by VRF HVAC system manufacturer, slope refrigerant piping and tubing as follows:
1. Install horizontal hot-gas discharge piping and tubing with a uniform slope downward away from compressor.
 2. Install horizontal suction lines with a uniform slope downward to compressor.
 3. Install traps to entrain oil in vertical runs.
 4. Liquid lines may be installed level.
- I. When brazing, remove or protect components that could be damaged by heat.
- J. Before installation, clean piping, tubing, and fittings to cleanliness level required by VRF HVAC system manufacturer.
- K. Joint Construction:
1. Ream ends of tubes and remove burrs.
 2. Remove scale, slag, dirt, and debris from inside and outside of tube and fittings before assembly.
 3. Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.
 - a. Use Type BCuP (copper-phosphorus) alloy for joining copper fittings with copper tubing.
 - b. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze.

3.8 INSTALLATION OF METAL HANGERS AND SUPPORTS

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- B. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
- C. Comply with MFMA-103 for metal framing system selections and applications that are not specified.
- D. Fastener System Installation:
 - 1. Install powder-actuated fasteners, for use in lightweight concrete or concrete slabs less than 4 inches thick, in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 - 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
 - 3. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.
- E. Pipe Stand Installation:
 - 1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 - 2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.
- F. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- G. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- H. Install lateral bracing with pipe hangers and supports to prevent swaying.
- I. Install building attachments within concrete slabs or attach to structural steel.
 - 1. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- J. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- K. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

L. Piping and Tubing Insulation:

1. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
2. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.

M. Horizontal-Piping Hangers and Supports: Install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
3. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
4. Multiple horizontal pipes located indoors may use metal framing systems with split clamp attachment for each pipe in lieu of individual clevis hangers.
5. Pipe stands for horizontal pipes located outdoors.
6. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
7. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

N. Horizontal Piping Hanger Spacing and Rod Size: Install hangers for drawn-temper copper piping with the following maximum horizontal spacing and minimum rod sizes:

1. Sizes through NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/4: Maximum span, 7 feet; minimum rod size, 3/8 inch.
4. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
5. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
6. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
7. NPS 3 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch.

O. Plastic Pipe Hanger and Support Spacing:

1. Space hangers and supports according to pipe manufacturer's written instructions for service conditions.
2. Maximum spacing, 5 feet; minimum rod size, 1/4 inch.

P. Vertical-Piping Clamps: Install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8).
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): If longer ends are required for riser clamps.

Q. Support vertical runs at roof, at each floor, and at midpoint intervals between floors, not to exceed 5 feet.

- R. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified.
- S. Use hangers, supports, and attachments with galvanized coatings unless otherwise indicated.
- T. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- U. Trim excess length of continuous-thread hanger and support rods to 1 inch.
- V. Hanger-Rod Attachments: Install the following types:
 - 1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
 - 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
 - 3. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 - 4. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.
- W. Building Attachments: Install the following types:
 - 1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 - 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
 - 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 - 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 - 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 - 6. C-Clamps (MSS Type 23): For structural shapes.
 - 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 - 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 - 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 - 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 - 11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 - 12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
 - 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 - 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 - 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

3.9 INSTALLATION OF PIPING AND TUBING INSULATION

- A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated. Installation to maintain a continuous vapor barrier.
- B. Insulation Installation on Pipe Fittings and Elbows:
 - 1. Install mitered sections of pipe insulation.
 - 2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C. Insulation Installation on Valves and Pipe Specialties:
 - 1. Install preformed valve covers manufactured of same material as pipe insulation when available.
 - 2. When preformed valve covers are unavailable, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - 3. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- D. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.
 - 1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- E. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.10 INSTALLATION OF DUCT, ACCESSORIES, AND AIR OUTLETS

- A. Where installing ductwork adjacent to equipment, allow space for service and maintenance.
- B. Comply with requirements for metal ducts specified in Section 233113 "Metal Ducts."
- C. Comply with requirements for nonmetal ducts specified in Section 233116 "Nonmetal Ducts."
- D. Comply with requirements for air duct accessories specified in Section 233300 "Air Duct Accessories."
- E. Comply with requirements for flexible ducts specified in Section 233346 "Flexible Ducts."
- F. Comply with requirements for air diffusers specified in Section 233713.13 "Air Diffusers."

- G. Comply with requirements for registers and grilles specified in Section 233713.23 "Registers and Grilles."

3.11 ELECTRICAL INSTALLATION

- A. Comply with requirements indicated on Drawings and in applicable Division 26 Sections.
- B. To extent electrical power is required for system equipment, components, and controls, and is not indicated on Drawings and addressed in the Specifications, the design for such electrical power shall be delegated to VRF HVAC system provider.
 - 1. Delegated design of electrical power to equipment, components and controls, and associated installation shall be included at no additional cost to Owner.
- C. Connect field electrical power source to each separate electrical device requiring field electrical power. Coordinate termination point and connection type with Installer.
- D. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.
- E. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding connections.
- F. Install nameplate or acrylic label with self-adhesive back for each electrical connection indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated phenolic layers of black with engraved white letters. Letters at least 1/2 inch high.
 - 2. Locate nameplate or label where easily visible.
- G. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for raceway selection and installation requirements for boxes, conduits, and wireways as supplemented or revised in this Section.
 - 1. Outlet boxes shall be no smaller than 2 inches wide, 3 inches high, and 2-1/2 inches deep.
 - 2. Outlet boxes for cables shall be no smaller than 4 inches square by 1-1/2 inches deep with extension ring sized to bring edge of ring to within 1/8 inch of the finished wall surface.
 - 3. Flexible metal conduit shall not be used.
- H. Comply with TIA-569-D for pull-box sizing and length of conduit and number of bends between pull points.
- I. Install manufactured conduit sweeps and long-radius elbows if possible.
- J. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

3.12 SOFTWARE

A. Cybersecurity:

1. Software:

- a. Coordinate security requirements with IT department.
- b. Ensure that latest stable software release is installed and properly operating.
- c. Disable or change default passwords to password using a combination of uppercase and lower letters, numbers, and symbols at least eight characters in length. Record passwords and turn over to party responsible for system operation and administration.

2. Hardware:

- a. Coordinate location and access requirements with IT department.
- b. Enable highest level of wireless encryption that is compatible with Owner's ICT network.
- c. Disable dual network connections.

3.13 INSTALLATION OF SYSTEM CONTROL CABLE

A. Comply with NECA 1.

B. Installation Method:

1. Install cables in raceways except as follows:

- a. Within equipment and associated control enclosures.
- b. In accessible ceiling spaces where open cable installation method may be used.
- c. In gypsum board partitions where cable may be enclosed within wall cavity.

2. Conceal raceway and cables except in unfinished spaces.

C. General Requirements for Cabling:

1. Comply with TIA-568-C Series of standards.
2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems."
3. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
4. Cables may not be spliced and shall be continuous from terminal to terminal. Do not splice cable.
5. Cables serving a common system may be grouped in a common raceway. Install control cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
6. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.

7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Install lacing bars and distribution spools.
8. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.
9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Monitor cable pull tensions.
11. Support: Do not allow cables to lie on removable ceiling tiles or access panels.
12. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.
13. Provide strain relief.
14. Keep runs short. Allow extra length for connecting to terminals.
15. Do not bend cables in a radius less than 10 times the cable OD.
16. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
17. Ground wire shall be copper, and grounding methods shall comply with IEEE C2. Demonstrate ground resistance.

D. Balanced Twisted-Pair Cable Installation:

1. Comply with TIA-568-C.2.
2. Do not untwist balanced twisted-pair cables more than 1/2 inch at the point of termination to maintain cable geometry.

E. Open-Cable Installation:

1. Suspend copper cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 30 inches apart.
2. Cable shall not be run through or on structural members or in contact with pipes, ducts, or other potentially damaging items. Do not run cables between structural members and corrugated panels.

F. Separation from EMI Sources: Comply with BICSI TDMM and TIA-569-D recommendations for separating unshielded cable from potential EMI sources including electrical power wiring and equipment.

3.14 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-D, Annex A, "Firestopping."
- C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.15 GROUNDING INSTALLATION

- A. For data communication wiring, comply with TIA-607-B and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.
- B. For low-voltage control cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.16 IDENTIFICATION

- A. Identify system equipment, piping, tubing, and valves. Comply with requirements for identification specified in Section 230553 "Identification for HVAC Piping and Equipment."
- B. Identify system electrical components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
 - 1. Identify each control cable on each end and at each terminal with a number-coded identification tag. Each cable shall have a unique tag.

3.17 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage VRF HVAC system manufacturer's service representative to advise and assist installers; witness testing; and observe and inspect components, assemblies, and equipment installations, including controls and connections.
 - 1. Field service shall be performed by a factory-trained and -authorized service representative of VRF HVAC system manufacturer whose primary job responsibilities are to provide direct technical support of its products.
 - a. Additional factory-authorized representatives may assist with completion of certain activities only if supervised by manufacturer's employee. A factory-authorized representative shall not provide assistance without manufacturer's employee supervision.
 - 2. Manufacturer shall provide on-site visits during the course of construction at installation milestones indicated. System Installer shall coordinate each visit in advance to give manufacturer sufficient notice to plan the visit.
 - a. First Visit: Kick-off meeting.
 - b. Second Visit: At approximately 25 percent completion of system(s).
 - c. Third Visit: At approximately 50 percent completion of system(s).
 - d. Fourth Visit: At approximately 75 percent completion of system(s).
 - e. Fifth Visit: Final inspection before system startup.
 - 3. Kick-off Meeting:

- a. Meeting shall include system Installer and other related trades with sole purpose of reviewing VRF HVAC system installation requirements and close coordination required to make a successful installation.
 - b. Meeting shall be held at Project site and scheduled at a mutually agreed to time that occurs before the start of any part of system installation.
 - c. Meeting shall cover the following as a minimum requirement:
 - 1) Review of latest issue of Contract Documents, Drawings, and Specifications, relevant to VRF HVAC systems.
 - 2) Manufacturer's installation requirements specific to systems being installed.
 - 3) Review of all relevant VRF HVAC system submittals, including delegated-design submittals.
 - 4) Required field activities related installation of VRF HVAC system.
 - 5) Project team communication protocol, contact information, and exchange of responsibilities for each party involved, including manufacturer, supplier, system Installer, and other related trades.
4. Site Visits: Activities for each site visit shall include the following:
- a. Meet with VRF HVAC system Installer to discuss field activities, issues, and suggested methods to result in a successful installation.
 - b. Offer technical support to Installer and related trades as related to VRF system(s) being installed.
 - c. Review progress of VRF HVAC system(s) installation for strict compliance with manufacturer's requirements.
 - d. Advise and if necessary assist Installer with updating related refrigerant calculations and system documentation.
 - e. Issue a report for each visit, documenting the visit.
 - 1) Report to include name and contact information of individual making the visit.
 - 2) Date(s) and time frames while on-site.
 - 3) Names and contact information of people meeting with while on-site.
 - 4) Clearly identify and list each separate issue that requires resolution. For each issue, provide a unique identification number, relevant importance, specific location or equipment identification, description of issue, recommended corrective action, and follow-up requirements needed. Include a digital photo for clarification if deemed to be beneficial.
5. Final Inspection before Startup:
- a. Before inspection, Installer to provide written request to manufacturer stating the system is fully installed according manufacturer's requirements and ready for final inspection.
 - b. All system equipment and operating components shall be inspected. If components are inaccessible for inspection, they shall be made accessible before the final inspection can be completed.
 - c. Manufacturer shall provide a comprehensive inspection of all equipment and each operating component that comprise the complete system(s). Inspection shall follow a detailed checklist specific to each equipment and operating component.

- d. Inspection reports for indoor units shall include, but not be limited to, the following:
- 1) Unit designation on Drawings.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Network address, if applicable.
 - 5) Each equipment setting.
 - 6) Mounting, supports, and restraints properly installed.
 - 7) Proper service clearance provided.
 - 8) Wiring and power connections correct.
 - 9) Line-voltage reading(s) within acceptable range.
 - 10) Wiring and controls connections correct.
 - 11) Low-voltage reading(s) within an acceptable range.
 - 12) Controller type and model controlling unit.
 - 13) Controller location.
 - 14) Temperature settings and readings within an acceptable range.
 - 15) Humidity settings and readings within an acceptable range.
 - 16) Condensate removal acceptable.
 - 17) Fan settings and readings within an acceptable range.
 - 18) Unit airflow direction within an acceptable range.
 - 19) If applicable, fan external static pressure setting.
 - 20) Filter type and condition acceptable.
 - 21) Noise level within an acceptable range.
 - 22) Refrigerant piping properly connected and insulated.
 - 23) Condensate drain piping properly connected and insulated.
 - 24) If applicable, ductwork properly connected.
 - 25) If applicable, external interlocks properly connected.
 - 26) Remarks.
- e. Inspection reports for outdoor units shall include, but not be limited to, the following:
- 1) Unit designation on Drawings.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Network address, if applicable.
 - 5) Each equipment setting.
 - 6) Mounting, supports, and restraints properly installed.
 - 7) Proper service clearance provided.
 - 8) Wiring and power connections correct.
 - 9) Line-voltage reading(s) within acceptable range.
 - 10) Wiring and controls connections correct.
 - 11) Low-voltage reading(s) within an acceptable range.
 - 12) Condensate removal acceptable.
 - 13) Noise level within an acceptable range.
 - 14) Refrigerant piping properly connected and insulated.
 - 15) Condensate drain piping properly connected and insulated.
 - 16) Remarks.

- f. Inspection reports for indoor, dedicated outdoor air ventilation units shall include, but not be limited to, the following:
- 1) Unit designation on Drawings.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Network address, if applicable.
 - 5) Each equipment setting.
 - 6) Mounting, supports, and restraints properly installed.
 - 7) Proper service clearance provided.
 - 8) Wiring and power connections correct.
 - 9) Line-voltage reading(s) within acceptable range.
 - 10) Wiring and controls connections correct.
 - 11) Low-voltage reading(s) within an acceptable range.
 - 12) Controller type and model controlling unit.
 - 13) Controller location.
 - 14) Temperature settings and readings within an acceptable range.
 - 15) Humidity settings and readings within an acceptable range.
 - 16) Condensate removal acceptable.
 - 17) Fan settings and readings within an acceptable range.
 - 18) Fan external static pressure setting.
 - 19) Filter type and condition acceptable.
 - 20) Noise level within an acceptable range.
 - 21) Refrigerant piping properly connected and insulated.
 - 22) Condensate drain piping properly connected and insulated.
 - 23) Automatic dampers properly installed and operating.
 - 24) Ductwork properly connected.
 - 25) If applicable, external interlocks properly connected.
 - 26) Remarks.
- g. Inspection reports for energy recovery ventilators shall include, but not be limited to, the following:
- 1) Unit designation on Drawings.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Network address, if applicable.
 - 5) Each equipment setting.
 - 6) Mounting, supports, and restraints properly installed.
 - 7) Proper service clearance provided.
 - 8) Wiring and power connections correct.
 - 9) Line-voltage reading(s) within acceptable range.
 - 10) Wiring and controls connections correct.
 - 11) Low-voltage reading(s) within an acceptable range.
 - 12) Controller type and model controlling unit.
 - 13) Controller location.
 - 14) Temperature settings and readings within an acceptable range.
 - 15) Humidity readings.
 - 16) Condensate removal acceptable.
 - 17) Fan settings and readings within an acceptable range.

- 18) Fan external static pressure setting.
- 19) Filter type and condition acceptable.
- 20) Noise level within an acceptable range.
- 21) Automatic dampers properly installed and operating.
- 22) Ductwork properly connected.
- 23) If applicable, external interlocks properly connected.
- 24) Remarks.

h. Inspection reports for hydronic units shall include, but not be limited to, the following:

- 1) Unit designation on Drawings.
- 2) Manufacturer model number.
- 3) Serial number.
- 4) Network address, if applicable.
- 5) Each equipment setting.
- 6) Mounting, supports, and restraints properly installed.
- 7) Proper service clearance provided.
- 8) Wiring and power connections correct.
- 9) Line-voltage reading(s) within acceptable range.
- 10) Wiring and controls connections correct.
- 11) Low-voltage reading(s) within an acceptable range.
- 12) Controller type and model controlling unit.
- 13) Controller location.
- 14) Temperature settings and readings within an acceptable range.
- 15) Condensate removal acceptable.
- 16) Noise level within an acceptable range.
- 17) Refrigerant piping properly connected and insulated.
- 18) Hydronic piping properly connected and insulated.
- 19) Proof of water flow checked for proper operation.
- 20) Condensate drain piping properly connected and insulated.
- 21) If applicable, external interlocks properly connected.
- 22) Remarks.

- i. Installer shall provide manufacturer with the requested documentation and technical support during inspection.
- j. Installer shall correct observed deficiencies found by the inspection.
- k. Upon completing the on-site inspection, manufacturer shall provide a written report with complete documentation describing each inspection step, the result, and any corrective action required.
- l. If corrective action is required by Installer that cannot be completed during the same visit, provide additional visits, as required, until deficiencies are resolved and systems are deemed ready for startup.
- m. Final report shall indicate the system(s) inspected are installed according to manufacturer's requirements and are ready for startup.

B. Perform the following tests and inspections with the assistance of manufacturer's service representative:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Refrigerant Tubing Positive Pressure Testing:

1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
2. After completion of tubing installation, pressurize tubing systems to a test pressure of not less than 1.2 times VRF HVAC system operating pressure, but not less than 600 psig, using dry nitrogen.
3. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of 24 hours. Allowance for pressure changes attributed to changes in ambient temperature are acceptable.
4. Prepare test report to record the following information for each test:
 - a. Name of person starting test, company name, phone number, and e-mail address.
 - b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
 - c. Detailed description of extent of tubing tested.
 - d. Date and time at start of test.
 - e. Test pressure at start of test.
 - f. Outdoor temperature at start of test.
 - g. Name of person ending test, company name, phone number, and e-mail address.
 - h. Date and time at end of test.
 - i. Test pressure at end of test.
 - j. Outdoor temperature at end of test.
 - k. Remarks:
5. Submit test reports for Project record.

D. Refrigerant Tubing Evacuation Testing:

1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
2. After completion of tubing positive-pressure testing, evacuate tubing systems to a pressure of 500 microns.
3. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of one hour(s) with no change.
4. Prepare test report to record the following information for each test:
 - a. Name of person starting test, company name, phone number, and e-mail address.
 - b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
 - c. Detailed description of extent of tubing tested.

- d. Date and time at start of test.
 - e. Test pressure at start of test.
 - f. Outdoor temperature at start of test.
 - g. Name of person ending test, company name, phone number, and e-mail address.
 - h. Date and time at end of test.
 - i. Test pressure at end of test.
 - j. Outdoor temperature at end of test.
 - k. Remarks:
5. Submit test reports for Project record.
 6. Upon successful completion of evacuation testing, system shall be charged with refrigerant.
- E. System Refrigerant Charge:
1. Using information collected from the refrigerant tubing evacuation testing, system Installer shall consult variable refrigerant system manufacturer to determine the correct system refrigerant charge.
 2. Installer shall charge system following VRF HVAC system manufacturer's written instructions.
 3. System refrigerant charging shall be witnessed by system manufacturer's representative.
 4. Total refrigerant charge shall be recorded and permanently displayed at the system's outdoor unit.
- F. Products will be considered defective if they do not pass tests and inspections.
- G. Prepare test and inspection reports.

3.18 STARTUP SERVICE

- A. Engage a VRF HVAC system manufacturer's service representative to perform system(s) startup service.
1. Service representative shall be a factory-trained and -authorized service representative of VRF HVAC system manufacturer.
 2. Complete startup service of each separate system.
 3. Complete system startup service according to manufacturer's written instructions.
- B. Startup checks shall include, but not be limited to, the following:
1. Check control communications of equipment and each operating component in system(s).
 2. Check each indoor unit's response to demand for cooling and heating.
 3. Check each indoor unit's response to changes in airflow settings.
 4. Check each indoor unit and outdoor unit for proper condensate removal.
 5. Check sound levels of each indoor unit.
- C. Installer shall accompany manufacturer's service representative during startup service and provide manufacturer's service representative with requested documentation and technical support during startup service.

1. Installer shall correct deficiencies found during startup service for reverification.

D. System Operation Report:

1. After completion of startup service, manufacturer shall issue a report for each separate system.
2. Report shall include complete documentation describing each startup check, the result, and any corrective action required.
3. Manufacturer shall electronically record not less than two hours of continuous operation of each system and submit with report for historical reference.
 - a. All available system operating parameters shall be included in the information submitted.

E. Witness:

1. Invite Architect Owner and Commissioning Agent to witness startup service procedures.
2. Provide written notice not less than 20 business days before start of startup service.

3.19 ADJUSTING

- A. Adjust equipment and components to function smoothly, and lubricate as recommended by manufacturer.
- B. Adjust initial temperature and humidity set points. Adjust initial airflow settings and discharge airflow patterns.
- C. Set field-adjustable switches and circuit-breaker trip ranges according to VRF HVAC system manufacturer's written instructions, and as indicated.
- D. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.20 PROTECTION

- A. Protect products from moisture and water damage. Remove and replace products that are wet, moisture damaged, or mold damaged.
- B. Protect equipment from physical damage. Replace equipment with physical damage that cannot be repaired to new condition. Observable surface imperfections shall be grounds for removal and replacement.
- C. Protect equipment from electrical damage. Replace equipment suffering electrical damage.
- D. Cover and seal openings of equipment to keep inside of equipment clean. Do not remove covers until finish work is complete.

3.21 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of system Installer who are manufacturer's authorized service representative. Include two service visits for preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper equipment and system operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.22 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.
- B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
 - 1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.23 DEMONSTRATION

- A. Engage a VRF HVAC system manufacturer's factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain entire system.
- B. Instructor:
 - 1. Instructor shall be factory trained and certified by VRF HVAC system manufacturer with current training on the system(s), equipment, and controls that are installed.
 - 2. Instructor's credentials shall be submitted for review by Architect before scheduling training.
 - 3. Instructor(s) primary job responsibility shall be Owner training.
 - 4. Instructor(s) shall have not less than three years of training experience with VRF HVAC system manufacturer and past training experience on at least three projects of comparable size and complexity.
- C. Schedule and Duration:
 - 1. Schedule training with Owner at least 20 business days before first training session.
 - 2. Training shall occur before Owner occupancy.
 - 3. Training shall be held at mutually agreed date and time during normal business hours.
 - 4. Each training day shall not exceed eight hours of training. Daily training schedule shall allow time for one-hour lunch period and 15-minute break after every two hours of training.
 - 5. Perform not less than eight total hours of training.

- D. Location: Owner shall provide a suitable on-site location to host classroom training.
- E. Training Attendees: Assume three people.
- F. Training Attendance: For record purposes, document training attendees at the start of each new training session. Record attendee's name, signature, phone number, and e-mail address.
- G. Training Format: Individual training modules shall include classroom training followed by hands-on field demonstration and training.
- H. Training Materials: Provide training materials in electronic format to each attendee.
 - 1. Include instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
 - 2. Video record each classroom training session and submit an electronic copy to Owner before requesting Owner acceptance of training.
- I. Acceptance: Obtain Architect or Owner written acceptance that training is complete and requirements indicated have been satisfied.

END OF SECTION 238129

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Testing, Adjusting, and Balancing of Air Systems:
 - a. Constant-volume air systems.
 - 2. Testing, adjusting, and balancing of equipment.
 - 3. Duct leakage tests verification.

1.3 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. NEBB: National Environmental Balancing Bureau.
- C. TAB: Testing, adjusting, and balancing.
- D. TABB: Testing, Adjusting, and Balancing Bureau.
- E. TAB Specialist: An independent entity meeting qualifications to perform TAB work.
- F. TDH: Total dynamic head.
- G. UFAD: Underfloor air distribution.

1.4 PREINSTALLATION MEETINGS

- A. TAB Conference: Conduct a TAB conference at [**Project site**] <**Insert location**> after approval of the TAB strategies and procedures plan, to develop a mutual understanding of the details. Provide a minimum of [**14**] <**Insert number**> days' advance notice of scheduled meeting time and location.
 - 1. Minimum Agenda Items:
 - a. The Contract Documents examination report.
 - b. The TAB plan.
 - c. Needs for coordination and cooperation of trades and subcontractors.
 - d. Proposed procedures for documentation and communication flow.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report, as specified in Part 3.
- C. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures, as specified in "Preparation" Article.
- D. System Readiness Checklists: Within 30 days of Contractor's Notice to Proceed, submit system readiness checklists, as specified in "Preparation" Article.
- E. Examination Report: Submit a summary report of the examination review required in "Examination" Article.
- F. Certified TAB reports.
- G. Sample report forms.
- H. Instrument calibration reports, to include the following:
 - 1. Instrument type and make.
 - 2. Serial number.
 - 3. Application.
 - 4. Dates of use.
 - 5. Dates of calibration.

1.6 QUALITY ASSURANCE

- A. TAB Specialists Qualifications, Certified by AABC:
 - 1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
 - 2. TAB Technician: Employee of the TAB specialist and certified by AABC.
- B. TAB Specialists Qualifications, Certified by NEBB or TABB:
 - 1. TAB Field Supervisor: Employee of the TAB specialist and certified by NEBB or TABB.
 - 2. TAB Technician: Employee of the TAB specialist and certified by NEBB or TABB.
- C. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."
- E. Code and AHJ Compliance: TAB is required to comply with governing codes and requirements of authorities having jurisdiction.

1.7 FIELD CONDITIONS

- A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.
- B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.
- B. Examine installed systems for balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine ceiling plenums and underfloor air plenums used for HVAC to verify that they are properly separated from adjacent areas and sealed.
- F. Examine equipment performance data, including fan and pump curves.
 - 1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
 - 2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.
- G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- H. Examine test reports specified in individual system and equipment Sections.

- I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.
- J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.
- K. Examine temporary and permanent strainers. Verify that temporary strainer screens used during system cleaning and flushing have been removed and permanent strainer baskets are installed and clean.
- L. Examine control valves for proper installation for their intended function of isolating, throttling, diverting, or mixing fluid flows.
- M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- N. Examine system pumps to ensure absence of entrained air in the suction piping.
- O. Examine operating safety interlocks and controls on HVAC equipment.
- P. Examine control dampers for proper installation for their intended function of isolating, throttling, diverting, or mixing air flows.
- Q. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

- A. Prepare a TAB plan that includes the following:
 - 1. Equipment and systems to be tested.
 - 2. Strategies and step-by-step procedures for balancing the systems.
 - 3. Instrumentation to be used.
 - 4. Sample forms with specific identification for all equipment.
- B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
 - 1. Airside:
 - a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
 - b. Duct systems are complete with terminals installed.
 - c. Volume, smoke, and fire dampers are open and functional.
 - d. Clean filters are installed.
 - e. Fans are operating, free of vibration, and rotating in correct direction.
 - f. Variable-frequency controllers' startup is complete and safeties are verified.
 - g. Automatic temperature-control systems are operational.
 - h. Ceilings are installed.
 - i. Windows and doors are installed.
 - j. Suitable access to balancing devices and equipment is provided.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system in accordance with the procedures contained in AABC's "National Standards for Total System Balance" and in this Section.
- B. Cut insulation, ducts, pipes, and equipment casings for installation of test probes to the minimum extent necessary for TAB procedures.
 - 1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
 - 2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
 - 3. Where holes for probes are required in piping or hydronic equipment, install pressure and temperature test plugs to seal systems.
 - 4. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish in accordance with Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."
- C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 TESTING, ADJUSTING, AND BALANCING OF HVAC EQUIPMENT

- A. Test, adjust, and balance HVAC equipment indicated on Drawings, including, but not limited to, the following:
 - 1. Motors.
 - 2. Fans and ventilators.
 - 3. Condensing units.
 - 4. Air-handling units.
 - 5. Split-system air conditioners.
 - 6. Heat pumps.
 - 7. Unit ventilators.

3.5 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' Record drawings duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling-unit components.

3.6 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 - 1. Measure total airflow.
 - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
 - b. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.
 - c. Where duct conditions are unsuitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
 - 2. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - b. Measure static pressure directly at the fan inlet or through the flexible connection.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report artificial loading of filters at the time static pressures are measured.
 - 3. Review Contractor-prepared shop drawings and Record drawings to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
 - 4. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
 - 5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
 - 1. Measure airflow of submain and branch ducts.
 - 2. Adjust submain and branch duct volume dampers for specified airflow.
 - 3. Re-measure each submain and branch duct after all have been adjusted.
- C. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
 2. Measure inlets and outlets airflow.
 3. Adjust each inlet and outlet for specified airflow.
 4. Re-measure each inlet and outlet after they have been adjusted.
- D. Verify final system conditions.
1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
 2. Re-measure and confirm that total airflow is within design.
 3. Re-measure all final fan operating data, speed, volts, amps, and static profile.
 4. Mark all final settings.
 5. Test system in economizer mode. Verify proper operation and adjust if necessary.
 6. Measure and record all operating data.
 7. Record final fan-performance data.

3.7 PROCEDURES FOR AIR-COOLED CONDENSING UNITS

- A. Verify proper rotation of fan(s).
- B. Measure and record entering- and leaving-air temperatures.
- C. Measure and record entering and leaving refrigerant pressures.
- D. Measure and record operating data of compressor(s), fan(s), and motors.

3.8 DUCT LEAKAGE TESTS

- A. Witness the duct leakage testing performed by Installer.
- B. Verify that proper test methods are used and that leakage rates are within specified limits.
- C. Report deficiencies observed.

3.9 HVAC CONTROLS VERIFICATION

- A. In conjunction with system balancing, perform the following:
 1. Verify HVAC control system is operating within the design limitations.
 2. Confirm that the sequences of operation are in compliance with Contract Documents.
 3. Verify that controllers are calibrated and function as intended.
 4. Verify that controller set points are as indicated.
 5. Verify the operation of lockout or interlock systems.
 6. Verify the operation of valve and damper actuators.
 7. Verify that controlled devices are properly installed and connected to correct controller.
 8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
 9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

- B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.10 TOLERANCES

- A. Set HVAC system's airflow rates and water flow rates within the following tolerances:
 - 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent . If design value is less than 100 cfm, within 10 cfm.
 - 2. Air Outlets and Inlets: Plus or minus 10 percent. If design value is less than 100 cfm, within 10 cfm.
- B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.11 PROGRESS REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for system-balancing devices. Recommend changes and additions to system-balancing devices, to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance-measuring and -balancing devices.
- B. Status Reports: Prepare biweekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.12 FINAL REPORT

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
 - 1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
 - 2. Include a list of instruments used for procedures, along with proof of calibration.
 - 3. Certify validity and accuracy of field data.
- B. Final Report Contents: In addition to certified field-report data, include the following:
 - 1. Manufacturers' test data.
 - 2. Field test reports prepared by system and equipment installers.
 - 3. Other information relative to equipment performance; do not include Shop Drawings and Product Data.
- C. General Report Data: In addition to form titles and entries, include the following data:
 - 1. Title page.
 - 2. Name and address of the TAB specialist.
 - 3. Project name.
 - 4. Project location.
 - 5. Architect's name and address.

6. Engineer's name and address.
 7. Contractor's name and address.
 8. Report date.
 9. Signature of TAB supervisor who certifies the report.
 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 11. Summary of contents, including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 12. Nomenclature sheets for each item of equipment.
 13. Data for terminal units, including manufacturer's name, type, size, and fittings.
 14. Notes to explain why certain final data in the body of reports vary from indicated values.
 15. Test conditions for fans performance forms, including the following:
 - a. Settings for outdoor-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Heating coil, dry-bulb conditions.
 - e. Face and bypass damper settings at coils.
 - f. Fan drive settings, including settings and percentage of maximum pitch diameter.
 - g. Inlet vane settings for variable-air-volume systems.
 - h. Settings for pressure controller(s).
 - i. Other system operating conditions that affect performance.
 16. Test conditions for pump performance forms, including the following:
 - a. Variable-frequency controller settings for variable-flow hydronic systems.
 - b. Settings for pressure controller(s).
 - c. Other system operating conditions that affect performance.
- D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
1. Quantities of outdoor, supply, return, and exhaust airflows.
 2. Water and steam flow rates.
 3. Duct, outlet, and inlet sizes.
 4. Pipe and valve sizes and locations.
 5. Terminal units.
 6. Balancing stations.
 7. Position of balancing devices.
- E. Air-Handling-Unit Test Reports: For air-handling units, include the following:
1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Unit arrangement and class.
 - g. Discharge arrangement.
 - h. Sheave make, size in inches, and bore.
 - i. Center-to-center dimensions of sheave and amount of adjustments in inches.

- j. Number, make, and size of belts.
 - k. Number, type, and size of filters.
 - 2. Motor Data:
 - a. Motor make, and frame type and size.
 - b. Horsepower and speed.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Center-to-center dimensions of sheave and amount of adjustments in inches.
 - 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan speed.
 - d. Inlet and discharge static pressure in inches wg.
 - e. For each filter bank, filter static-pressure differential in inches wg.
 - f. Preheat-coil static-pressure differential in inches wg.
 - g. Cooling-coil static-pressure differential in inches wg.
 - h. Heating-coil static-pressure differential in inches wg.
 - i. List for each internal component with pressure-drop, static-pressure differential in inches wg.
 - j. Outdoor airflow in cfm.
 - k. Return airflow in cfm.
 - l. Outdoor-air damper position.
- F. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
 - 1. Report Data:
 - a. System fan and air-handling-unit number.
 - b. Location and zone.
 - c. Traverse air temperature in deg F.
 - d. Duct static pressure in inches wg.
 - e. Duct size in inches.
 - f. Duct area in sq. ft..
 - g. Indicated airflow rate in cfm.
 - h. Indicated velocity in fpm.
 - i. Actual airflow rate in cfm.
 - j. Actual average velocity in fpm.
 - k. Barometric pressure in psig.
- G. Air-Terminal-Device Reports:
 - 1. Unit Data:
 - a. System and air-handling unit identification.
 - b. Location and zone.
 - c. Apparatus used for test.
 - d. Area served.
 - e. Make.
 - f. Number from system diagram.
 - g. Type and model number.
 - h. Size.
 - i. Effective area in sq. ft..

2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Air velocity in fpm.
 - c. Preliminary airflow rate as needed in cfm.
 - d. Preliminary velocity as needed in fpm.
 - e. Final airflow rate in cfm.
 - f. Final velocity in fpm.
 - g. Space temperature in deg F.

3.13 VERIFICATION OF TAB REPORT

- A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Construction Manager.
- B. Construction Manager shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to the lesser of either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
- C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
- D. If the number of "FAILED" measurements is greater than 20 percent of the total measurements checked during the final inspection, the TAB shall be considered incomplete and shall be rejected.
- E. If recheck measurements find the number of failed measurements noncompliant with requirements indicated, proceed as follows:
 1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection. All changes shall be tracked to show changes made to previous report.
 2. If the second final inspection also fails, Owner may pursue others Contract options to complete TAB work.
- F. Prepare test and inspection reports.

3.14 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
- B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 230593

SECTION 230713 - DUCT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes insulating the following duct services:
 - 1. Indoor, concealed supply and outdoor air.
 - 2. Indoor, exposed supply and outdoor air.
 - 3. Indoor, concealed return located in unconditioned space.
 - 4. Indoor, exposed return located in unconditioned space.
 - 5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
 - 6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
- B. Related Requirements:
 - 1. Section 233113 "Metal Ducts" for duct liners.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
 - 3. Detail application of field-applied jackets.
 - 4. Detail application at linkages of control devices.
- C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:
 - 1. Sheet Form Insulation Materials: 12 inches square.
 - 2. Sheet Jacket Materials: 12 inches square.
 - 3. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
- C. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or craft training program, certified by the Department of Labor, Bureau of Apprenticeship and Training.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers are to be marked with the manufacturer's name, appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.
 - 1. All Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2.2 INSULATION MATERIALS

- A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials are to be applied.
- B. Products do not contain asbestos, lead, mercury, or mercury compounds.

- C. Products that come in contact with stainless steel have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.
- D. Insulation materials for use on austenitic stainless steel are qualified as acceptable in accordance with ASTM C795.
- E. Foam insulation materials do not use CFC or HCFC blowing agents in the manufacturing process.
- F. Flexible Elastomeric: Closed-cell or expanded-rubber materials; suitable for maximum use temperature between minus 70 deg F and 220 deg F. Comply with ASTM C534, Type II for sheet materials.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aeroflex USA.
 - b. Armacell LLC.
 - c. K-Flex USA.
- G. Glass-Fiber Blanket: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 450 deg F in accordance with ASTM C411. Comply with ASTM C553, Type II, and ASTM C1290, [Type I, unfaced] [Type II with factory-applied vinyl jacket] [Type III with factory-applied FSK jacket] [Type III with factory-applied FSP jacket]. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide [product indicated on Drawings] <insert manufacturer name, product name or designation> or comparable product by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Certainteed; SAINT-GOBAIN.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. Knauf Insulation.
 - d. Manson Insulation Inc.
 - e. Owens Corning.

2.3 ADHESIVES

- A. Materials are compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aeroflex USA.

- b. Armacell LLC.
 - c. Childers Brand; H. B. Fuller Construction Products.
 - d. Foster Brand; H. B. Fuller Construction Products.
 - e. K-Flex USA.
- C. Glass-Fiber and Mineral Wool Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide [**product indicated on Drawings**] <insert manufacturer name, product name or designation> or comparable product by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Eagle Bridges - Marathon Industries.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. Mon-Eco Industries, Inc.
- D. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Eagle Bridges - Marathon Industries.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. Mon-Eco Industries, Inc.

2.4 LAGGING ADHESIVES

- A. Description: Comply with MIL-A-3316C, Class I, Grade A and are compatible with insulation materials, jackets, and substrates.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Vimasco Corporation.
 - 3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
 - 4. Service Temperature Range: 0 to plus 180 deg F.
 - 5. Color: White.

2.5 SEALANTS

- A. FSK and Metal Jacket Flashing Sealants:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Eagle Bridges - Marathon Industries.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. Mon-Eco Industries, Inc.
3. Materials are compatible with insulation materials, jackets, and substrates.
4. Fire- and water-resistant, flexible, elastomeric sealant.
5. Service Temperature Range: Minus 40 to plus 250 deg F.
6. Color: Aluminum.

B. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
3. Materials are compatible with insulation materials, jackets, and substrates.
4. Fire- and water-resistant, flexible, elastomeric sealant.
5. Service Temperature Range: Minus 40 to plus 250 deg F.
6. Color: White.

2.6 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
 3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
 4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.
 5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested in accordance with ASTM E96/E96M, Procedure A, and complying with NFPA 90A and NFPA 90B.
 6. ASJ+: All-service jacket composed of aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film leaving no paper exposed; complying with ASTM C1136, Types I, II, III, IV, and VII.
 7. PSK Jacket: Aluminum foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.

2.7 FIELD-APPLIED JACKETS

- A. Field-applied jackets comply with ASTM C921, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
- C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. P.I.C. Plastics, Inc.
 - c. Proto Corporation.
 - d. Speedline Corporation.
 - 3. Adhesive: As recommended by jacket material manufacturer.
 - 4. Color: White.
- D. Self-Adhesive Indoor/Outdoor Jacket (Non-Asphaltic): Vapor barrier and waterproofing jacket for installation over insulation located aboveground outdoors or indoors. Specialized jacket has five layers of laminated aluminum and polyester film with low-temperature acrylic pressure-sensitive adhesive. Outer aluminum surface is coated with UV-resistant coating for protection from environmental contaminants.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. H.B. Fuller Construction Products Inc.
 - d. Ideal Tape Co., Inc., an American Biltrite Company.
 - 3. Permeance: 0.00 perm as tested in accordance with ASTM F1249.
 - 4. Flamespread/Smoke Developed: 25/50 as tested in accordance with ASTM E84.
 - 5. Aluminum Finish: Embossed.

2.8 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M Industrial Adhesives and Tapes Division.
 - b. Avery Dennison Corporation, Specialty Tapes Division.

- c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
 - 3. Width: 3 inches.
 - 4. Thickness: 11.5 mils.
 - 5. Adhesion: 90 ounces force/inch in width.
 - 6. Elongation: 2 percent.
 - 7. Tensile Strength: 40 lbf/inch in width.
 - 8. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M Industrial Adhesives and Tapes Division.
 - b. Avery Dennison Corporation, Specialty Tapes Division.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
 - 3. Width: 3 inches.
 - 4. Thickness: 6.5 mils.
 - 5. Adhesion: 90 ounces force/inch in width.
 - 6. Elongation: 2 percent.
 - 7. Tensile Strength: 40 lbf/inch in width.
 - 8. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M Industrial Adhesives and Tapes Division.
 - b. Ideal Tape Co., Inc., an American Biltrite Company.
 - 3. Width: 2 inches.
 - 4. Thickness: 6 mils.
 - 5. Adhesion: 64 ounces force/inch in width.
 - 6. Elongation: 500 percent.
 - 7. Tensile Strength: 18 lbf/inch in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M Industrial Adhesives and Tapes Division.
 - b. Avery Dennison Corporation, Specialty Tapes Division.

- c. Ideal Tape Co., Inc., an American Biltrite Company.
- d. Knauf Insulation.
- e. Sekisui Voltek, LLC.
- 3. Width: 2 inches.
- 4. Thickness: 3.7 mils.
- 5. Adhesion: 100 ounces force/inch in width.
- 6. Elongation: 5 percent.
- 7. Tensile Strength: 34 lbf/inch in width.

2.9 SECUREMENTS

A. Bands:

- 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
- 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. RPR Products, Inc.
- 3. Stainless Steel: ASTM A240/A240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide with wing seal or closed seal.
- 4. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.
- 5. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

- 1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
 - a. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Midwest Fasteners, Inc.
 - 4) Nelson Stud Welding.
- 2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
 - a. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AGM Industries, Inc.
 - 2) CL WARD & Family Inc.

- 3) Gemco.
 - 4) Midwest Fasteners, Inc.
 - 5) Nelson Stud Welding.
3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Midwest Fasteners, Inc.
 - c. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
 - d. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
 - e. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Gemco.
 - 2) Midwest Fasteners, Inc.
 - c. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
 - d. Spindle: Nylon, 0.106-inch- diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
 - e. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Midwest Fasteners, Inc.

- c. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
 - d. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
 - e. Adhesive-backed base with a peel-off protective cover.
- 6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
 - a. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Midwest Fasteners, Inc.
 - 4) Nelson Stud Welding.
 - c. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
- 7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
 - a. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Gemco.
 - 2) Midwest Fasteners, Inc.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.
- D. Wire: [0.080-inch nickel-copper alloy.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. C & F Wire Products.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. RPR Products, Inc.

2.10 CORNER ANGLES

- A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC in accordance with ASTM D1784, Class 16354-C. White or color-coded to match adjacent surface.
- B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum in accordance with ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

- C. Stainless Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel in accordance with ASTM A240/A240M, Type 304 or Type 316.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 - 1. Verify that systems to be insulated have been tested and are free of defects.
 - 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.
- B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Keep insulation materials dry during application and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with Contract Documents.
- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.
- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- K. Install insulation with factory-applied jackets as follows:
1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.
 2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.
- L. Cut insulation in a manner to avoid compressing insulation.
- M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
1. Seal penetrations with flashing sealant.

2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 4. Seal jacket to wall flashing with flashing sealant.
- C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
1. Comply with requirements in Section 078413 "Penetration Firestopping."
- E. Insulation Installation at Floor Penetrations:
1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."
- 3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC AND POLYOLEFIN INSULATION
- A. Comply with manufacturer's written installation instructions and ASTM C1710.
- B. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C. Square and Rectangular Ducts and Plenums:
1. Provide 1/4 inch more per side for a tight, compression fit.
 2. Cut sheet insulation with the following dimensions:
 - a. Width of duct plus 1/4 inch, one piece.
 - b. Height of duct plus 1/4 inch, plus thickness of insulation, two pieces.
 - c. Width of duct plus 1/4 inch, plus two times the thickness of insulation, one piece.
 3. Insulate the bottom of the duct with the sheet from (a) above, then the sides with the two sheets from (b) above, and finally the top of the duct with the sheet from (c) above.
 4. Insulation without self-adhering backing:
 - a. Apply 100 percent coverage of manufacturer adhesive on the metal surface, then the insulation, except for the last 1/4 inch where sheets will butt together.
 - b. Roll sheet down into position.
 - c. Press two sheets together under compression and apply adhesive at the butt joint to seal the two sheets together.
 5. Insulation with self-adhering backing:
 - a. Peel back release paper in 6- to 8-inch increments and line up sheet.
 - b. Press firmly to activate adhesive.
 - c. Align material and continue to line up correctly, pressing firmly while slowly removing release paper.

- d. Allow 1/4-inch overlap for compression at butt joints.
- e. Apply adhesive at the butt joint to seal the two sheets together.
6. Insulate duct brackets following manufacturer's written installation instructions.

D. Circular Ducts:

1. Determine the circumference of the duct, using a strip of insulation the same thickness as to be used.
2. Cut the sheet to the required size.
3. Apply 100 percent coverage of manufacturer adhesive on the metal surface then the insulation.
4. Apply manufacturer adhesive to the cut surfaces along 100 percent of the longitudinal seam. Press together the seam at the ends and then the middle. Close the entire seam starting from the middle.

3.6 INSTALLATION OF GLASS-FIBER AND MINERAL-WOOL INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

B. Comply with manufacturer's written installation instructions.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Impale insulation over pins and attach speed washers.
 - f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover

- insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
 6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.
- C. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
 5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.7 FIELD-APPLIED JACKET INSTALLATION

- A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
 - 1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
 - 2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
 - 3. Completely encapsulate insulation with coating, leaving no exposed insulation.
- B. Where FSK jackets are indicated, install as follows:
 - 1. Draw jacket material smooth and tight.
 - 2. Install lap or joint strips with same material as jacket.
 - 3. Secure jacket to insulation with manufacturer's recommended adhesive.
 - 4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
 - 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.
 - 1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless steel bands 12 inches o.c. and at end joints.

3.8 FIRE-RATED INSULATION SYSTEM INSTALLATION

- A. Comply with manufacturer's written installation instructions.
- B. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.
- C. Insulate duct access panels and doors to achieve same fire rating as duct.
- D. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 078413 "Penetration Firestopping."

3.9 FINISHES

- A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."
 - 1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.

- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- D. Do not field paint aluminum or stainless steel jackets.

3.10 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Tests and Inspections:
 - 1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection is limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.
- D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.11 DUCT INSULATION SCHEDULE, GENERAL

- A. Plenums and Ducts Requiring Insulation:
 - 1. Indoor, concealed supply and outdoor air.
 - 2. Indoor, concealed return located in unconditioned space.
 - 3. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
- B. Items Not Insulated:
 - 1. Fibrous-glass ducts.
 - 2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
 - 3. Factory-insulated flexible ducts.
 - 4. Factory-insulated plenums and casings.
 - 5. Flexible connectors.
 - 6. Vibration-control devices.
 - 7. Factory-insulated access panels and doors.

3.12 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

- A. Concealed, round and flat-oval, supply-air duct insulation is one of the following:
 - 1. Flexible Elastomeric: 1 inch thick.
 - 2. Glass-Fiber Blanket: 1-1/2 inches thick and 0.75 lb/cu. ft. nominal density.
- B. Concealed, round and flat-oval, outdoor-air duct insulation is one of the following:
 - 1. Flexible Elastomeric: 1 inch thick.
 - 2. Glass-Fiber Blanket: 1-1/2 inches thick and 0.75 lb/cu. ft. nominal density.

- C. Concealed, round and flat-oval, exhaust-air duct insulation is one of the following:
 - 1. Flexible Elastomeric: 1 inch thick.
 - 2. Glass-Fiber Blanket: 1-1/2 inches thick and 0.75 lb/cu. ft. nominal density.
- D. Concealed, rectangular, supply-air duct insulation is one of the following:
 - 1. Flexible Elastomeric: 1 inch thick.
 - 2. Glass-Fiber Blanket: 1-1/2 inches thick and 0.75 lb/cu. ft. nominal density.
- E. Concealed, rectangular, return-air duct insulation is **one of** the following:
 - 1. Flexible Elastomeric: 1 inch thick.
 - 2. Glass-Fiber Blanket: 1-1/2 inches thick and 0.75 lb/cu. ft. nominal density.
- F. Concealed, supply-air plenum insulation is one of the following:
 - 1. Flexible Elastomeric: 1 inch thick.
 - 2. Glass-Fiber Blanket: 1-1/2 inches thick and 0.75 lb/cu. ft. nominal density.
- G. Concealed, return-air plenum insulation is one of the following:
 - 1. Flexible Elastomeric: 1 inch thick.
 - 2. Glass-Fiber Blanket: 1-1/2 inches thick and 0.75 lb/cu. ft. nominal density.

3.13 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Ducts and Plenums, Concealed:
 - 1. None.
 - 2. PVC: 20 mils thick.
 - 3. Aluminum, Smooth: 0.016 inch thick.
 - 4. Painted Aluminum, Smooth: 0.016 inch thick.
 - 5. Stainless Steel, Type 304 or Type 316, Smooth 2B Finish: 0.010 inch thick.

END OF SECTION 230713

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Single-wall rectangular ducts and fittings.
 - 2. Single-wall round ducts and fittings.
 - 3. Sheet metal materials.
 - 4. Sealants and gaskets.
 - 5. Hangers and supports.
- B. Related Requirements:
 - 1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
 - 2. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.2 DEFINITIONS

- A. OSHPD: Office of Statewide Health Planning and Development (State of California).

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of the following products:
 - 1. Liners and adhesives.
 - 2. Sealants and gaskets.
 - 3. Seismic-restraint devices.
- B. Shop Drawings:
 - 1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
 - 2. Factory- and shop-fabricated ducts and fittings.
 - 3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
 - 4. Elevation of top of ducts.
 - 5. Dimensions of main duct runs from building grid lines.
 - 6. Fittings.
 - 7. Reinforcement and spacing.
 - 8. Seam and joint construction.
 - 9. Penetrations through fire-rated and other partitions.
 - 10. Equipment installation based on equipment being used on Project.
 - 11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
 - 12. Hangers and supports, including methods for duct and building attachment and vibration isolation.
 - 13.

- C. Delegated Design Submittals:
 - 1. Sheet metal thicknesses.
 - 2. Joint and seam construction and sealing.
 - 3. Reinforcement details and spacing.
 - 4. Materials, fabrication, assembly, and spacing of hangers and supports.
 - 5. Design Calculations: Calculations for selecting hangers and supports.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: A single set of plans or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Welding certificates.
- C. Field quality-control reports.

1.5 QUALITY ASSURANCE

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and with performance requirements and design criteria indicated in "Duct Schedule" Article.
- B. Structural Performance: Duct hangers and supports are to withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"
- C. Airstream Surfaces: Surfaces in contact with airstream comply with requirements in ASHRAE 62.1.
- D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."
- E. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
- F. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation or duct wall thickness.

2.2 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
 - 1. Construct ducts of galvanized sheet steel unless otherwise indicated.
 - 2. For ducts exposed to weather, construct of Type 304 stainless steel indicated by manufacturer to be suitable for outdoor installation.
- B. Transverse Joints: Fabricate joints in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. For ducts with longest side less than 36 inches, select joint types in accordance with Figure 2-1.
 - 2. For ducts with longest side 36 inches or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.
- C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SINGLE-WALL ROUND DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
 - 1. Construct ducts of galvanized sheet steel unless otherwise indicated.
 - 2. For ducts exposed to weather, construct of Type 304 stainless steel indicated by manufacturer to be suitable for outdoor installation.
 - 3. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 4. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Elgen Manufacturing.
 - b. GreenSeam.
 - c. Linx Industries; a DMI company (formerly Lindab).
 - d. MKT Metal Manufacturing.
 - e. McGill AirFlow LLC.
 - f. Nordfab Ducting.

- g. SEMCO, LLC; part of FlaktGroup.
 - h. Set Duct Manufacturing.
 - i. Sheet Metal Connectors, Inc.
 - j. Spiral Manufacturing Co., Inc.
 - k. Stamped Fittings Inc.
- B. Source Limitations: Obtain single-wall round ducts and fittings from single manufacturer.
- C. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).
- D. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
- E. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
 - 2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.
- F. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.4 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials are to be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A653/A653M.
 - 1. Galvanized Coating Designation: G60.
 - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. PVC-Coated, Galvanized Sheet Steel: Comply with ASTM A653/A653M.
 - 1. Galvanized Coating Designation: G60.
 - 2. Minimum Thickness for Factory-Applied PVC Coating: 4 mils thick.
 - 3. Coating Materials: Acceptable to authorities having jurisdiction for use on ducts listed and labeled by an NRTL for compliance with UL 181, Class 1.

- D. Carbon-Steel Sheets: Comply with ASTM A1008/A1008M, with oiled, matte finish for exposed ducts.
- E. Stainless Steel Sheets: Comply with ASTM A480/A480M, Type 304 or 316, as indicated in "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish is to be No. 2B, No. 2D, No. 3, or No. 4 as indicated in "Duct Schedule" Article.
- F. Aluminum Sheets: Comply with ASTM B209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.
- G. Factory- or Shop-Applied Antimicrobial Coating:
 - 1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating is to be applied to the exterior surface.
 - 2. Antimicrobial compound is to be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 - 3. Coating containing the antimicrobial compound is to have a hardness of 2H, minimum, when tested in accordance with ASTM D3363.
 - 4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
 - 5. Shop-Applied Coating Color: Black.
 - 6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.
- H. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.
 - 1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- I. Tie Rods: Galvanized steel, 1/4-inch- minimum diameter for lengths 36 inches or less; 3/8-inch- minimum diameter for lengths longer than 36 inches.

2.5 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets are to be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
- B. Two-Part Tape Sealing System:
 - 1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
 - 2. Tape Width: 3 inches.
 - 3. Sealant: Modified styrene acrylic.
 - 4. Water resistant.
 - 5. Mold and mildew resistant.
 - 6. Maximum Static-Pressure Class: 10 inch wg, positive and negative.
 - 7. Service: Indoor and outdoor.
 - 8. Service Temperature: Minus 40 to plus 200 deg F.

9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10 inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Solvent-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Base: Synthetic rubber resin.
3. Solvent: Toluene and heptane.
4. Solids Content: Minimum 60 percent.
5. Shore A Hardness: Minimum 60.
6. Water resistant.
7. Mold and mildew resistant.
8. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
9. Service: Indoor or outdoor.
10. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. Flanged Joint Sealant: Comply with ASTM C920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.

F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

G. Round Duct Joint O-Ring Seals:

1. Seal is to provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and is to be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.6 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

- C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A603.
- E. Steel Cables for Stainless Steel Ducts: Stainless steel complying with ASTM A492.
- F. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- H. Trapeze and Riser Supports:
 - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
 - 2. Supports for Stainless Steel Ducts: Stainless steel shapes and plates.
 - 3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and coordination drawings.
- B. Install ducts in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install ducts in maximum practical lengths with fewest possible joints.
- D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- G. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

- I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.
- J. Install fire] and smoke dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers and specific installation requirements of the damper UL listing.
- K. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.
- L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation.
- M. Elbows: Use long-radius elbows wherever they fit.
 - 1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
 - 2. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.
- N. Branch Connections: Use lateral or conical branch connections.

3.2 DUCT SEALING

- A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- B. Seal ducts at a minimum to the following seal classes in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
 - 1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 2. Outdoor, Supply-Air Ducts: Seal Class A.
 - 3. Outdoor, Exhaust Ducts: Seal Class C.
 - 4. Outdoor, Return-Air Ducts: Seal Class C.
 - 5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
 - 6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
 - 7. Unconditioned Space, Exhaust Ducts: Seal Class C.
 - 8. Unconditioned Space, Return-Air Ducts: Seal Class B.
 - 9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
 - 10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
 - 11. Conditioned Space, Exhaust Ducts: Seal Class B.
 - 12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.3 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Where practical, install concrete inserts before placing concrete.
 - 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
 - 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
 - 5. Do not use powder-actuated concrete fasteners for seismic restraints. Coordinate with Section 230548 "Vibration and Seismic Controls for HVAC."
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
- D. Hangers Exposed to View: Threaded rod and angle or channel supports.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.4 DUCTWORK CONNECTIONS

- A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.5 PAINTING

- A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

3.6 FIELD QUALITY CONTROL

- A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:
 - a. Ducts with a Pressure Class Higher Than 3-Inch wg: Test representative duct sections totaling no less than 25 percent of total installed duct area for each designated pressure class.
 - b. Supply Ducts with a Pressure Class of 2- Inch wg or Higher: Test representative duct sections totaling no less than 50 percent of total installed duct area for each designated pressure class.
 - c. Return Ducts with a Pressure Class of 2- Inch wg or Higher: Test representative duct sections totaling no less than 50 percent of total installed duct area for each designated pressure class.
3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Testing of each duct section is to be performed with access doors, coils, filters, dampers, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.
5. Test for leaks before applying external insulation.
6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
7. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness in accordance with "Description of Method 3 - NADCA Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
 - a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media is to not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 DUCT CLEANING

- A. Clean new duct system(s) before testing, adjusting, and balancing.
- B. For cleaning of existing ductwork, see Section 230130.52 "Existing HVAC Air Distribution System Cleaning."
- C. Use duct cleaning methodology as indicated in NADCA ACR.
- D. Use service openings for entry and inspection.
 1. Provide openings with access panels appropriate for duct static-pressure and leakage class at dampers, coils, and any other locations where required for inspection and cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and

- liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
 - 2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
 - 3. Remove and reinstall ceiling to gain access during the cleaning process.
- E. Particulate Collection and Odor Control:
- 1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
 - 2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.
- F. Clean the following components by removing surface contaminants and deposits:
- 1. Air outlets and inlets (registers, grilles, and diffusers).
 - 2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
 - 3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
 - 4. Coils and related components.
 - 5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
 - 6. Supply-air ducts, dampers, actuators, and turning vanes.
 - 7. Dedicated exhaust and ventilation components and makeup air systems.
- G. Mechanical Cleaning Methodology:
- 1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
 - 2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
 - 3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
 - 4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
 - 5. Clean coils and coil drain pans in accordance with NADCA ACR. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
 - 6. Provide drainage and cleanup for wash-down procedures.
 - 7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents in accordance with manufacturer's written instructions after removal of surface deposits and debris.

3.8 STARTUP

- A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.9 DUCT SCHEDULE

- A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:
 - 1. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as indicated below.
- B. Supply Ducts:
 - 1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units :
 - a. Pressure Class: Positive 2-inch wg.
 - b. Minimum SMACNA Seal Class: C.
 - c. SMACNA Leakage Class for Rectangular: 16.
 - d. SMACNA Leakage Class for Round and Flat Oval: 8.
- C. Return Ducts:
 - 1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units :
 - a. Pressure Class: Positive or negative 1-inch wg.
 - b. Minimum SMACNA Seal Class: C.
 - c. SMACNA Leakage Class for Rectangular: 16.
 - d. SMACNA Leakage Class for Round and Flat Oval: 8.
- D. Exhaust Ducts:
 - 1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
 - a. Pressure Class: Negative 1-inch wg.
 - b. Minimum SMACNA Seal Class: C if negative pressure, and A if positive pressure.
 - c. SMACNA Leakage Class for Rectangular: 16.
 - d. SMACNA Leakage Class for Round and Flat Oval: 8.
- E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:
 - 1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units :
 - a. Pressure Class: Positive or negative 1-inch wg.
 - b. Minimum SMACNA Seal Class: C.
 - c. SMACNA Leakage Class for Rectangular: 16.
 - d. SMACNA Leakage Class for Round and Flat Oval: 8.
- F. Elbow Configuration:
 - 1. Rectangular Duct - Requirements for Different Velocities: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Velocity 1000 fpm or Lower:
 - 1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
 - 2) Mitered Type RE 4 without vanes.
 - b. Velocity 1000 to 1500 fpm:
 - 1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
 - c. Velocity 1500 fpm or Higher:
 - 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.

- 2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
 2. Rectangular Duct - Requirements for All Velocities: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
 3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
 - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - 1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
 - 2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
 - 3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
 - 4) Radius-to Diameter Ratio: 1.5.
 - b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
 - c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.
- G. Branch Configuration:
 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.
 - b. Rectangular Main to Round Branch: Conical spin in.
 2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
 - a. Velocity 1000 fpm or Lower: 90-degree tap.
 - b. Velocity 1000 to 1500 fpm: Conical tap.
 - c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 233113

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Backdraft and pressure relief dampers.
 - 2. Manual volume dampers.
 - 3. Fire dampers.
 - 4. Flange connectors.
 - 5. Turning vanes.
 - 6. Duct-mounted access doors.
 - 7. Duct accessory hardware.
- B. Related Requirements:
 - 1. Section 233346 "Flexible Ducts" for insulated and non-insulated flexible ducts.
 - 2. Section 233723 "HVAC Gravity Ventilators" for roof-mounted ventilator caps.
 - 3. Section 284621.11 "Addressable Fire-Alarm Systems" for duct-mounted fire and smoke detectors.
 - 4. Section 284621.13 "Conventional Fire-Alarm Systems" for duct-mounted fire and smoke detectors.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. For duct silencers, include pressure drop, dynamic insertion loss, and self-generated noise data. Include breakout noise calculations for high-transmission-loss casings.
- B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail duct accessories' fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
 - a. Special fittings.
 - b. Manual volume damper installations.
 - c. Control-damper installations.
 - d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor-damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
 - e. Duct security bars.
 - f. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, or BIM model, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from installers of the items involved.
- B. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Comply with NFPA 90A and NFPA 90B.
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 BACKDRAFT AND PRESSURE RELIEF DAMPERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. American Warming and Ventilating (AWV); Mestek, Inc.
 - 2. Cesco Products; MESTEK, Inc.
 - 3. Greenheck Fan Corporation.
 - 4. Lloyd Industries, Inc.
 - 5. NCA Manufacturing, Inc.; Metal Industries, Inc.
 - 6. Nailor Industries Inc.
 - 7. Pottorff.
 - 8. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
 - 9. Safe Air - Dowco.
 - 10. United Enertech Corp.

- 11. Vent Products Co., Inc.
- C. Description: Gravity balanced.
- D. Performance:
 - 1. Maximum Air Velocity: 1000 fpm.
 - 2. Maximum System Pressure: 1 inch wg.
 - 3. Leakage:
 - a. Class IA: Leakage shall not exceed 3 cfm/sq. ft. against 1-inch wg differential static pressure.
 - b. Class I: Leakage shall not exceed 4 cfm/sq. ft. against 1-inch wg differential static pressure.
 - c. Class II: Leakage shall not exceed 10 cfm/sq. ft. against 1-inch wg differential static pressure.
 - d. Class III: Leakage shall not exceed 40 cfm/sq. ft. against 1-inch wg differential static pressure.
- E. Construction:
 - 1. Frame:
 - a. Hat shaped.
 - b. 16-gauge- thick, galvanized sheet steel 0.093-inch- thick extruded aluminum, with welded or mechanically attached corners.
 - 2. Blades:
 - a. Multiple single-piece blades.
 - b. Center pivoted, maximum 6-inch width, 16-gauge- thick, 0.050-inch- thick aluminum sheet with sealed edges.
 - 3. Blade Action: Parallel.
- F. Blade Seals: **Extruded vinyl, mechanically locked.**
- G. Blade Axles:
 - 1. Material: Galvanized steel.
 - 2. Diameter: 0.20 inch.
- H. Tie Bars and Brackets: Galvanized steel.
- I. Return Spring: Adjustable tension.
- J. Bearings: Steel ball or synthetic pivot bushings.
- K. Damper Actuator - Electric:
 - 1. Electric - 120 V ac.
 - 2. UL 873 plenum rated.
 - 3. Two position with fail-safe spring return.
 - a. Sufficient motor torque and spring torque to drive damper fully closed with adequate force to achieve required damper seal.
 - b. Minimum 90-degree drive rotation.
 - 4. Clockwise or counterclockwise drive rotation as required for application.
 - 5. Environmental Operating Range:
 - a. Temperature: Minus 40 to plus 130 deg F.

- b. Humidity: 5 to 95 percent relative humidity noncondensing.
- 6. Environmental Enclosure: NEMA 2.
- 7. Actuator to be factory mounted and provided with a single-point wiring connection.
- L. Controllers, Electrical Devices, and Wiring:
 - 1. Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
 - 2. Electrical Connection: 115 V, single phase, 60 Hz.
- M. Accessories:
 - 1. Adjustment device to permit setting for varying differential static pressure.
 - 2. Counterweights and spring-assist kits for vertical airflow installations.
 - 3. Chain pulls.
 - 4. Screen Mounting:
 - a. Front mounted in sleeve.
 - 1) Sleeve Thickness: 20 gauge minimum.
 - 2) Sleeve Length: 6 inches minimum.
 - 5. Screen Material: Galvanized steel.
 - 6. Screen Type: Bird.
 - 7. 90-degree stops.

2.3 MANUAL VOLUME DAMPERS

- A. Standard, Steel, Manual Volume Dampers:
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Air Balance; MESTEK, Inc.
 - b. Aire Technologies, Inc.; DMI Companies.
 - c. American Warming and Ventilating (AWV); Mestek, Inc.
 - d. Arrow United Industries; Mestek, Inc.
 - e. Cesco Products; MESTEK, Inc.
 - f. Greenheck Fan Corporation.
 - g. Lloyd Industries, Inc.
 - h. McGill AirFlow LLC.
 - i. Nailor Industries Inc.
 - j. Pottorff.
 - k. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
 - l. Safe Air - Dowco.
 - m. United Enertech Corp.
 - n. Vent Products Co., Inc.
 - 3. Performance:
 - a. Leakage Rating Class III: Leakage not exceeding 40 cfm/sq. ft. against 1-inch wg differential static pressure.
 - 4. Construction:
 - a. Linkage out of airstream.
 - b. Suitable for horizontal or vertical airflow applications.
 - 5. Frames:

- a. Hat-shaped, 16-gauge- thick, galvanized sheet steel.
 - b. Mitered and welded corners.
 - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
 6. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Galvanized steel; 16 gauge thick.
 7. Blade Axles: Galvanized steel.
 8. Bearings:
 - a. Oil-impregnated bronze.
 - b. Dampers mounted with vertical blades to have thrust bearing at each end of every blade.
 9. Tie Bars and Brackets: Galvanized steel.
 10. Locking device to hold damper blades in a fixed position without vibration.
- B. Standard, Aluminum, Manual Volume Dampers:
1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Warming and Ventilating (AWV); Mestek, Inc.
 - b. Arrow United Industries; Mestek, Inc.
 - c. CESCO Products; MESTEK, Inc.
 - d. Linx Industries; a DMI company (formerly Lindab).
 - e. Lloyd Industries, Inc.
 - f. McGill AirFlow LLC.
 - g. Nailor Industries Inc.
 - h. Pottorff.
 - i. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
 - j. Safe Air - Dowco.
 - k. United Enertech Corp.
 - l. Vent Products Co., Inc.
 3. Performance:
 - a. Leakage Rating Class III: Leakage not exceeding 40 cfm/sq. ft. against 1-inch wg differential static pressure.
 4. Construction:
 - a. Linkage out of airstream.
 - b. Suitable for horizontal or vertical airflow applications.
 5. Frames:
 - a. Hat-shaped, 0.10-inch- thick, aluminum sheet channels.
 - b. Flanges for attaching to walls and flangeless frames for installing in ducts.
 6. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Roll-Formed Aluminum Blades: 0.10-inch- thick aluminum sheet.
 - e. Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.
 7. Blade Axles: Galvanized steel.
 8. Bearings:

- a. Oil-impregnated bronze.
- b. Dampers mounted with vertical blades to have thrust bearing at each end of every blade.
9. Tie Bars and Brackets: Aluminum.
10. Locking device to hold damper blades in a fixed position without vibration.

2.4 FIRE DAMPERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Air Balance; MESTEK, Inc.
 2. Aire Technologies, Inc.; DMI Companies.
 3. Arrow United Industries; Mestek, Inc.
 4. CL WARD & Family Inc.
 5. Cesco Products; MESTEK, Inc.
 6. Greenheck Fan Corporation.
 7. NCA Manufacturing, Inc.; Metal Industries, Inc.
 8. Pottorff.
 9. Prefco.
 10. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
 11. Safe Air - Dowco.
 12. United Enertech Corp.
 13. Vent Products Co., Inc.
- C. Type: Static and dynamic; rated and labeled in accordance with UL 555 by an NRTL.
- D. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000 fpm velocity.
- E. Fire Rating: 3 hours.
- F. Frame: Curtain type with blades inside airstream; fabricated with roll-formed galvanized steel; with mitered and interlocking corners; gauge in accordance with UL listing.
- G. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel; gauge in accordance with UL listing.
- H. Mounting Orientation: Vertical or horizontal as indicated.
- I. Blades: Roll-formed galvanized sheet steel, interlocking. Material gauge is to be in accordance with UL listing.
- J. Horizontal Dampers: Include blade lock and stainless steel closure spring.
- K. Heat-Responsive Device:
 1. Replaceable, 165 deg F rated, fusible links.

2.5 FLANGE CONNECTORS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. CL WARD & Family Inc.
 - 2. Ductmate Industries, Inc; a DMI company.
 - 3. DynAir; a Carlisle Company.
 - 4. Elgen Manufacturing.
 - 5. Ward Industries; a brand of Hart & Cooley, LLC.
- C. Description: Add-on or roll-formed, factory fabricated, slide-on transverse flange connectors, gaskets, and components.
- D. Material: Galvanized steel.
- E. Gauge and Shape: Match connecting ductwork.

2.6 TURNING VANES

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Aero-Dyne Sound Control Co.
 - 2. CL WARD & Family Inc.
 - 3. Ductmate Industries, Inc; a DMI company.
 - 4. Duro Dyne Inc.
 - 5. DynAir; a Carlisle Company.
 - 6. Elgen Manufacturing.
 - 7. Ward Industries; a brand of Hart & Cooley, LLC.
- C. Manufactured Turning Vanes for Metal Ducts: Fabricate curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
 - 1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.
- D. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- E. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
- F. Vane Construction:

1. Single wall.
2. Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.7 DUCT-MOUNTED ACCESS DOORS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Aire Technologies, Inc.; DMI Companies.
 2. Arrow United Industries; Mestek, Inc.
 3. CL WARD & Family Inc.
 4. Cesco Products; MESTEK, Inc.
 5. Ductmate Industries, Inc; a DMI company.
 6. Ductmate Industries, Inc; a DMI company.
 7. Duro Dyne Inc.
 8. Elgen Manufacturing.
 9. Flexmaster U.S.A., Inc.
 10. McGill AirFlow LLC.
 11. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
 12. United Enertech Corp.
 13. Ventfabrics, Inc.
 14. Ward Industries; a brand of Hart & Cooley, LLC.
- C. Duct-Mounted Access Doors: Fabricate access panels in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 7-2 (7-2M), "Duct Access Doors and Panels," and Figure 7-3, "Access Doors - Round Duct."
 1. Door:
 - a. Double wall, rectangular.
 - b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - c. 24-gauge- thick galvanized steel or 0.032-inch thick aluminum door panel.
 - d. Vision panel.
 - e. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
 - f. Fabricate doors airtight and suitable for duct pressure class.
 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 - a. 24-gauge- thick galvanized steel or 0.032-inch- thick aluminum frame.
 3. Number of Hinges and Locks:
 - a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
 - b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.

2.8 DUCT ACCESSORY HARDWARE

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. CL WARD & Family Inc.
2. Ductmate Industries, Inc; a DMI company.
3. Duro Dyne Inc.
4. DynAir; a Carlisle Company.
5. Elgen Manufacturing.
6. Hardcast; Carlisle Construction Materials.
7. United Eneritech Corp.
8. Ventfabrics, Inc.
9. Ward Industries; a brand of Hart & Cooley, LLC.

- C. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.
- D. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

2.9 MATERIALS

- A. Galvanized Sheet Steel: Comply with ASTM A653/A653M.
1. Galvanized Coating Designation: G60.
 2. Exposed-Surface Finish: Mill phosphatized.
- B. Stainless Steel Sheets: Comply with ASTM A480/A480M, Type 304, and having a No. 2 finish for concealed ducts.
- C. Aluminum Sheets: Comply with ASTM B209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, one-side bright finish for exposed ducts.
- D. Extruded Aluminum: Comply with ASTM B221, Alloy 6063, Temper T6.
- E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless steel ducts.
- F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install duct accessories in accordance with applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116 for fibrous-glass ducts.
- B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless steel accessories in stainless steel ducts, and aluminum accessories in aluminum ducts.

- C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- D. Where multiple damper sections are necessary to achieve required dimensions, provide reinforcement to fully support damper assembly when fully closed at full system design static pressure.
- E. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
 - 1. Install steel volume dampers in steel ducts.
 - 2. Install aluminum volume dampers in aluminum ducts.
- F. Set dampers to fully open position before testing, adjusting, and balancing.
- G. Install test holes at fan inlets and outlets and elsewhere as indicated and as needed for testing and balancing.
- H. Install fire dampers in accordance with UL listing.
- I. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - 1. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
 - 2. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
 - 3. Control devices requiring inspection.
 - 4. Elsewhere as indicated.
- J. Install access doors with swing against duct static pressure.
- K. Access Door Sizes:
 - 1. One-Hand or Inspection Access: 8 by 5 inches.
 - 2. Two-Hand Access: 12 by 6 inches.
 - 3. Head and Hand Access: 18 by 10 inches.
 - 4. Head and Shoulders Access: 21 by 14 inches.
 - 5. Body Access: 25 by 14 inches.
 - 6. Body plus Ladder Access: 25 by 17 inches.
- L. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
- M. Install flexible connectors to connect ducts to equipment.
- N. For fans developing static pressures of 5 inches wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- O. Install duct test holes where required for testing and balancing purposes.

- P. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Operate dampers to verify full range of movement.
 - 2. Inspect locations of access doors, and verify that size and location of access doors are adequate to perform required operation.
 - 3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and that proper heat-response device is installed.
 - 4. Inspect turning vanes for proper and secure installation, and verify that vanes do not move or rattle.
 - 5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 233300

SECTION 233713.13 – AIR DIFFUSERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Rectangular and square ceiling diffusers.
- B. Related Requirements:
 - 1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
 - 2. Diffuser Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.
- B. Samples: For each exposed product and for each color and texture specified. Actual size of smallest diffuser indicated.
- C. Samples for Initial Selection: For diffusers with factory-applied color finishes. Actual size of smallest diffuser indicated.
- D. Samples for Verification: For diffusers, in manufacturer's standard sizes to verify color selected. Actual size of smallest diffuser indicated.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Ceiling suspension assembly members.
 - 2. Method of attaching hangers to building structure.
 - 3. Size and location of initial access modules for acoustical tile.
 - 4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
 - 5. Duct access panels.

- B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 RECTANGULAR AND SQUARE CEILING DIFFUSERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. A-J Manufacturing Co., Inc.
 2. Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.
 3. Carnes Company.
 4. Hart & Cooley, LLC.
 5. Krueger-HVAC; brand of Johnson Controls International plc, Global Products.
 6. METALAIRE, Inc.
 7. Nailor Industries Inc.
 8. Price Industries Limited.
 9. Shoemaker Mfg. Co.
 10. Titus; brand of Johnson Controls International plc, Global Products.
 11. Tuttle & Bailey; brand of Johnson Controls International plc, Global Products.
- C. Devices shall be specifically designed for variable-air-volume flows.
- D. Material: Steel.
- E. Finish: Baked enamel, white.
- F. Face Size: 24 by 24 inches.
- G. Face Style: Three cone.
- H. Mounting: Surface.
- I. Pattern: Fixed.
- J. Dampers: Radial opposed blade.
- K. Accessories:
1. Equalizing grid.
 2. Plaster ring.
 3. Safety chain.
 4. Wire guard.
 5. Sectorizing baffles.
 6. Operating rod extension.

2.2 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate diffusers according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas where diffusers are installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install diffusers level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

- A. After installation, adjust diffusers to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713.13

SECTION 238129 - VARIABLE-REFRIGERANT-FLOW HVAC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes complete VRF HVAC system(s) including, but not limited to the following components to make a complete operating system(s) according to requirements indicated:
 - 1. Indoor, concealed, ceiling-mounted units for ducting.
 - 2.
 - 3. Indoor, energy recovery ventilator.
 - 4. Outdoor, air-source, heat-pump units.
 - 5. System controls.
 - 6. System refrigerant and oil.
 - 7. System condensate drain piping.
 - 8. System hydronic piping.
 - 9. System refrigerant piping.
 - 10. Metal hangers and supports.
 - 11. Metal framing systems.
 - 12. Fastener systems.
 - 13. Pipe stands.
 - 14. Equipment stands.
 - 15. Miscellaneous support materials.
 - 16. Piping and tubing insulation.
 - 17. System control cable and raceways.

1.3 DEFINITIONS

- A. Air-Conditioning System Operation: System capable of operation with all zones in cooling only.
- B. Heat-Pump System Operation: System capable of operation with all zones in either heating or cooling, but not with simultaneous heating and cooling zones that transfer heat between zones.
- C. Heat Recovery System Operation: System capable of operation with simultaneous heating and cooling zones that transfer heat between zones.
- D. HRCU: Heat Recovery Control Unit. HRCUs are used in heat recovery VRF HVAC systems to manage and control refrigerant between indoor units to provide simultaneous heating and

cooling zones. "Heat Recovery Control Unit" is the term used by ASHRAE for what different manufacturers term as branch circuit controller, branch selector box, changeover box, flow selector unit, mode change unit, and other such terms.

- E. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
- F. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.
- G. Three-Pipe System Design: One high pressure refrigerant vapor line, one low pressure refrigerant vapor line, and one refrigerant liquid line connect a single outdoor unit or multiple manifold outdoor units in a single system to associated system HRCUs. One liquid line and refrigerant vapor line connect HRCUs to associated indoor units.
- H. Two-Pipe System Design: One refrigerant vapor line and one refrigerant liquid line connect a single outdoor unit or multiple manifold outdoor units in a single system to associated system HRCUs. One refrigerant liquid line and refrigerant vapor line connect HRCUs to associated indoor units. HRCUs used in two pipe systems act as an intermediate heat exchanger and include diverting valves and gas/liquid separators to move high and low pressure refrigerant between indoor units.
- I. VRF: Variable refrigerant flow.

1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for indoor and outdoor units.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 3. Include operating performance at design conditions and at extreme maximum and minimum outdoor ambient conditions.
 - 4. Include description of system controllers, dimensions, features, control interfaces and connections, power requirements, and connections.
 - 5. Include system operating sequence of operation in narrative form for each unique indoor-and outdoor-unit control.
 - 6. Include description of control software features.
 - 7. Include total refrigerant required and a comprehensive breakdown of refrigerant required by each system installed.
 - 8. Include refrigerant type and data sheets showing compliance with requirements indicated.
 - 9. For system design software.

10. Indicate location and type of service access.

B. Shop Drawings: For VRF HVAC systems.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
4. Include diagrams and details of refrigerant piping and tubing showing installation requirements for manufacturer-furnished divided flow fittings.
5. Include diagrams for power, signal, and control wiring.

C. Samples for Initial Selection: For fully and partially exposed indoor units with factory finishes viewable by occupants.

1. Include a Sample for each unique finish with unit identification, detailed description of application, and cross-referenced floor plans showing locations.

D. Delegated-Design Submittals:

1. Include design calculations for selecting vibration isolators and for designing vibration isolation bases.
2. Include design calculations with corresponding diagram of refrigerant piping and tubing sizing for each system installed.
3. Include design calculations with corresponding floor plans indicating that refrigerant concentration limits are within allowable limits of ASHRAE 15 and governing codes.
4. Include calculations showing that system travel distance for refrigerant piping and controls cabling are within horizontal and vertical travel distances set by manufacturer. Provide a comparison table for each system installed.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, sections, and details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural floors, roofs and associated members to which equipment, piping, ductwork, cables, and conduit will be attached.
3. Size and location of initial access modules for acoustical tile.
4. Wall-mounted controllers located in finished space showing relationship to light switches, fire-alarm devices, and other installed devices.
5. Size and location of access doors and panels installed behind walls and inaccessible ceilings for products installed behind walls and requiring access.
6. Items penetrating finished ceiling including the following:

- a. Luminaires.
- b. Air outlets and inlets.
- c. Speakers.
- d. Sprinklers.
- e. Service access panels.

B. Qualification Data:

1. For Installer: Certificate from VRF HVAC system manufacturer certifying that Installer has successfully completed prerequisite training administered by manufacturer for proper installation of systems, including but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.
 - a. Retain copies of Installer certificates on-site and make available on request.
 2. For VRF HVAC system manufacturer.
 3. For VRF HVAC system provider.
- C. Product Test Reports: Where tests are required, for each product, for tests performed by manufacturer and witnessed by a qualified testing agency or a qualified testing agency.
- D. Source quality-control reports.
- E. Field quality-control reports.
- F. Sample Warranties: For manufacturer's warranties.

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For VRF HVAC systems to include in emergency, operation, and maintenance manuals.
- B. Software and Firmware Operational Documentation:
1. Software operating and upgrade manuals.
 2. Program Software Backup: On CD or DVD, USB media, or approved cloud storage platform, complete with data files.
 3. Device address list.
 4. Printout of software application and graphic screens.

1.8 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Filters:
 - a. One set(s) for each unit with replaceable filters.

- b. One set(s) for each unit type and unique size of washable filters.
- 2. Indoor Units: One for each unique size and type installed.
- 3. Controllers for Indoor Units: One for each unique controller type installed.

1.9 QUALITY ASSURANCE

A. Manufacturer Qualifications:

- 1. Nationally recognized manufacturer of VRF HVAC systems and products.
- 2. Shipped VRF HVAC systems with similar requirements to those indicated for a continuous period of five years within time of bid.
- 3. VRF HVAC systems and products that have been successfully tested and in use on at least three completed projects.
- 4. Having complete published catalog literature, installation, and operation and maintenance manuals for all products intended for use.
- 5. Having full-time in-house employees for the following:
 - a. Product research and development.
 - b. Product and application engineering.
 - c. Product manufacturing, testing, and quality control.
 - d. Technical support for system installation training, startup, commissioning, and troubleshooting of installations.
 - e. Owner training.

B. Factory-Authorized Service Representative Qualifications:

- 1. Authorized representative of, and trained by, VRF HVAC system manufacturer.
- 2. Demonstrated past experience with products being installed for period within three consecutive years before time of bid.
- 3. Demonstrated past experience on five projects of similar complexity, scope, and value.
 - a. Each person assigned to Project shall have demonstrated past experience.
- 4. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
- 5. Service and maintenance staff assigned to support Project during warranty period.
- 6. Product parts inventory to support ongoing system operation for a period of not less than five years after Substantial Completion.
- 7. VRF HVAC system manufacturer's backing to take over execution of Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

C. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by VRF HVAC system manufacturer.

- 1. Each employee shall be certified by manufacturer for proper installation of systems, including, but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.

2. Installer certification shall be valid and current for duration of Project.
3. Retain copies of Installer certificates on-site and make available on request.
4. Each person assigned to Project shall have demonstrated past experience.
 - a. Demonstrated past experience with products being installed for period within three consecutive years before time of bid.
 - b. Demonstrated past experience on five projects of similar complexity, scope, and value.

D. Mockups: Build mockups to set quality standards for materials and execution.

1. Build mockups to show a finished installation for each of the following applications:
 - a. For each different indoor unit type with exposed surfaces viewable by occupants.
2. Mockups shall be operational.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

E. ISO Compliance: System equipment and components furnished by VRF HVAC system manufacturer shall be manufactured in an ISO 9001 and ISO 14001 facility.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store products in a clean and dry place.
- B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.
- C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.
- D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.
 1. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.
 2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remove coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.
- E. Replace installed products damaged during construction.

1.11 WARRANTY

- A. **Manufacturer's Warranty:** Manufacturer agrees to repair or replace equipment and components that fail(s) in materials or workmanship within specified warranty period.
1. Failures include, but are not limited to, the following:
 - a. Structural failures.
 - b. Faulty operation.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal weathering and use.
 2. Warranty Period:
 - a. For Compressor: Five year(s) from date of Substantial Completion.
 - b. For Parts, Including Controls: Five year(s) from date of Substantial Completion.
 - c. For Labor: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. **Basis-of-Design Product:** Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
- B. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
1. Carrier Global Corporation.
 2. Daikin Applied.
 3. Fujitec America, Inc.
 4. Johnson Controls, Inc.
 5. LG Electronics USA, Inc.; LG Electronics Inc.
 6. Mitsubishi Electric & Electronics USA, Inc.
 7. Panasonic Corporation of North America.
 8. RectorSeal HVAC; a CSW Industrials Company.
 9. Samsung HVAC.
 10. Trane Inc.
- C. **Source Limitations:** Obtain products from single source from single manufacturer including, but not limited to, the following:
1. Indoor and outdoor units, including accessories.
 2. Controls and software.
 3. HRCUs.
 4. Refrigerant isolation valves.
 5. Specialty refrigerant pipe fittings.

2.2 SYSTEM DESCRIPTION

- A. Direct-expansion (DX) VRF HVAC system(s) with variable capacity in response to varying cooling and heating loads. System shall consist of multiple indoor units, outdoor unit(s), piping, controls, and electrical power to make complete operating system(s) complying with requirements indicated.
 - 1. Two-pipe system design.
 - 2. System(s) operation, heat pump as indicated on Drawings.
 - 3. Each system with one refrigerant circuit shared by all indoor units connected to system.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. AHRI Compliance: System and equipment performance certified according to AHRI 1230.
- D. ASHRAE Compliance:
 - 1. ASHRAE 15: For safety code for mechanical refrigeration.
 - 2. ASHRAE 62.1: For indoor air quality.
 - 3. ASHRAE 135: For control network protocol with remote communication.
 - 4. ASHRAE/IES 90.1 Compliance: For system and component energy efficiency.
- E. UL Compliance: Comply with UL 1995.

2.3 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional specialist, as defined in Section 014000 "Quality Requirements," to design complete and operational VRF HVAC system(s) complying with requirements indicated.
 - 1. Provide system refrigerant calculations.
 - a. Refrigerant concentration limits shall be within allowable limits of ASHRAE 15 and governing codes.
 - b. Indicate compliance with manufacturer's maximum vertical and horizontal travel distances. Prepare a comparison table for each system showing calculated distances compared to manufacturer's maximum allowed distances.
 - 2. Include a mechanical ventilation system and gas detection system as required to comply with ASHRAE 15 and governing codes.
 - 3. System Refrigerant Piping and Tubing:
 - a. Arrangement: Arrange piping to interconnect indoor units and outdoor unit(s) in compliance with manufacturer requirements and requirements indicated.
 - b. Routing: Conceal piping above ceilings and behind walls to maximum extent possible.

- c. Sizing: Size piping system, using a software program acceptable to manufacturer, to provide performance requirements indicated. Consider requirements to accommodate future change requirements.
 - 4. System Controls:
 - a. Network arrangement.
 - b. Network interface with other building systems.
 - c. Product selection.
 - d. Sizing.
- B. Service Access:
 - 1. Provide and document service access requirements.
 - 2. Locate equipment, system isolation valves, and other system components that require service and inspection in easily accessible locations. Avoid locations that are difficult to access if possible.
 - 3. Where serviceable components are installed behind walls and above inaccessible ceilings, provide finished assembly with access doors or panels to gain access. Properly size the openings to allow for service, removal, and replacement.
 - 4. If less than full and unrestricted access is provided, locate components within an 18-inch reach of the finished assembly.
 - 5. Where ladder access is required to service elevated components, provide an installation that provides for sufficient access within ladder manufacturer's written instructions for use.
 - 6. Comply with OSHA regulations.
- C. System Design and Installation Requirements:
 - 1. Design and install systems indicated according to manufacturer's recommendations and written instructions.
 - 2. Where manufacturer's requirements differ from requirements indicated, contact Architect for direction. The most stringent requirements should apply unless otherwise directed in writing by Architect.
- D. System Adaptability to Future Changes: Arrange and size system refrigerant piping to accommodate future changes to system without having to resize and replace existing refrigerant piping.
 - 1. Future changes to system(s) indicated on Drawings.
 - 2. Each branch circuit shall accommodate addition of **one** indoor unit(s) with unit capacity equal to **largest** indoor unit connected to the branch circuit.
 - 3. Each branch circuit shall accommodate deletion of **one** indoor unit(s) with unit capacity equal to **largest** indoor unit connected to the branch circuit.
- E. Isolation of Equipment: Provide isolation valves to isolate each indoor unit and outdoor unit for service, removal, and replacement without interrupting system operation.
- F. System Capacity Ratio: The sum of connected capacity of all indoor units shall be within the following range of outdoor-unit rated capacity:

1. Not less than **50** percent.
 2. Not more than **130** percent.
 3. Range acceptable to manufacturer.
- G. System Turndown: Stable operation down to 20 percent of outdoor-unit capacity.
- H. System Auto Refrigerant Charge: Each system shall have an automatic refrigerant charge function to ensure the proper amount of refrigerant is installed in system.
- I. Outdoor Conditions:
1. Suitable for outdoor ambient conditions encountered.
 - a. Design equipment and supports to withstand wind loads of governing code .
 - b. Design equipment and supports to withstand snow and ice loads of governing code .
 - c. Provide corrosion-resistant coating for components and supports where located in coastal or industrial climates that are known to be harmful to materials and finishes.
 2. Maximum System Operating Outdoor Temperature: See Drawings.
 3. Minimum System Operating Outdoor Temperature: See Drawings.
- J. Seismic Performance: VRF HVAC system(s) shall withstand the effects of earthquake motions determined according to .
1. The term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified."
 2. Component Importance Factor: 1.5.
- K. Sound Performance: Sound levels generated by operating HVAC equipment shall be within requirements indicated.
1. Indoor: See Drawings.
 2. Outdoor: See Drawings.
- L. Thermal Movements: Allow for controlled thermal movements from ambient, surface, and system temperature changes.
- M. Capacities and Characteristics: As indicated on Drawings.
- 2.4 INDOOR, CONCEALED, CEILING-MOUNTED UNITS FOR DUCTING
- A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.
- B. Cabinet:
1. Material: Galvanized or painted steel.

2. Insulation: Manufacturer's standard internal insulation to provide thermal resistance and prevent condensation.
3. Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.
4. Mounting: Manufacturer-designed provisions for field installation.
5. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:

1. Coil Casing: Aluminum, galvanized, or stainless steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
5. Unit Internal Tubing: Copper tubing with brazed joints.
6. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.
9. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.
3. Field Piping Connection: Non-ferrous material.

E. Fan and Motor Assembly:

1. Fan(s):
 - a. Direct-drive arrangement.
 - b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
 - c. Fabricated from non-ferrous components or ferrous components with corrosion-resistant finish.
 - d. Wheels statically and dynamically balanced.
2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:

1. Access: Bottom, side, or rear to accommodate field installation without removing ductwork and to accommodate filter replacement without need for tools.

2. Efficiency: ASHRAE 52.2, MERV 7.
3. Media:
 - a. Replaceable: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.
 - b. Washable: Manufacturer's standard filter with antimicrobial treatment.

G. Unit Accessories:

1. Outdoor Air Ventilation Kit: Connection, motorized damper, and control sized to allow sequence of operation indicated on Drawings.
2. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.

H. Unit Controls:

1. Enclosure: Metal, suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:
 - a. Unit inlet air temperature.
 - b. Coil entering refrigerant temperature.
 - c. Coil leaving refrigerant temperature.
4. Field-Customizable I/O Capability:
 - a. Analog Inputs: Two for use in customizable control strategies.
 - b. Digital Inputs: Two for use in customizable control strategies.
 - c. Digital Outputs: Two for use in customizable control strategies.
5. Features and Functions:
 - a. Self-diagnostics.
 - b. Time delay.
 - c. Auto-restart.
 - d. External static pressure control.
 - e. Auto operation mode.
 - f. Manual operation mode.
 - g. Filter service notification.
 - h. Power consumption display.
 - i. Drain assembly high water level safety shutdown and notification.
 - j. Run test switch.
6. Communication: Network communication with other indoor and outdoor units.
7. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
8. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

I. Unit Electrical:

1. Enclosure: Metal, suitable for indoor locations.
2. Field Connection: Single point connection to power unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in raceways.

2.5 INDOOR, ENERGY RECOVERY VENTILATOR

- A. Description: Factory-assembled complete unit with components, wiring, and controls required for mating to ductwork, power, and controls field connections.
- B. Cabinet:
 1. Material: Galvanized steel.
 2. Insulation: Manufacturer's standard internal insulation.
 3. Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.
 4. Mounting: Manufacturer-designed provisions for field installation.
 5. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
- C. Damper Assemblies:
 1. Outdoor Air Intake and Exhaust Air Discharge:
 - a. Low-leakage damper with spring return electric actuator to fail closed on loss of power.
 - b. Damper controlled by unit to open when unit is operating and close when unit off.
 2. Energy Recovery Heat-Exchanger Bypass:
 - a. Low leakage damper with electric actuator with integral controls to bypass outdoor air around the energy recovery heat exchanger during times of favorable weather, and there is no energy-saving benefit to circulate air across the energy recovery heat exchanger.
- D. Fan and Motor Assemblies: Separate fan and motor assemblies for supply and exhaust airstreams with control for equal airflow.
 1. Fan(s):
 - a. Direct-drive arrangement.
 - b. Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
 - c. Wheels statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
 3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
 4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
 5. Vibration Control: Integral isolation to dampen vibration transmission.
- E. Filter Assemblies: Separate filter assemblies for outdoor air and exhaust airstreams entering energy recovery heat exchanger.
1. Access: To accommodate filter replacement without the need for tools.
 2. Efficiency: ASHRAE 52.2, MERV 7.
 3. Replaceable Media: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.
- F. Energy Recovery Heat Exchanger:
1. Total (sensible and latent) energy exchange between outdoor air and exhaust airstreams with performance indicated on Drawings.
 2. Fixed element with no moving parts.
 3. AHRI 1060 certified and bearing the AHRI label.
- G. Unit Accessories:
1. Electric Duct Preheater:
 - a. Heater operation interlocked with energy recovery ventilator unit.
 - b. Heater with integral controls to control outdoor air temperature entering energy recovery ventilator unit to a temperature set-point determined by energy recovery ventilator unit manufacturer.
 - c. Listed and labeled.
- H. Unit Controls:
1. Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
 2. Factory-Installed Controller: Configurable digital control.
 3. Factory-Installed Sensors:
 - a. Unit entering outdoor air temperature.
 - b. Unit leaving supply air temperature.
 - c. Unit entering exhaust air temperature.
 - d. Unit leaving exhaust air temperature.
 - e. Unit entering outdoor air relative humidity.
 - f. Unit leaving supply air relative humidity.
 - g. Unit entering exhaust air relative humidity.
 - h. Unit leaving exhaust air relative humidity.
 - i. **<Insert sensor>**.
 4. Field-Customizable I/O Capability:
 - a. Analog Inputs: Two for use in customizable control strategies.

- b. Digital Inputs: Two for use in customizable control strategies.
- c. Digital Outputs: Two for use in customizable control strategies.
- 5. Features and Functions: Self-diagnostics, time delay, auto-restart.
- 6. Communication: Network communication with other indoor units and outdoor unit(s).
- 7. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
- 8. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

I. Unit Electrical:

- 1. Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
- 2. Field Connection: Single point connection to power entire unit and integral controls.
- 3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
- 4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
- 5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
- 6. Raceways: Enclose line voltage wiring in raceways to comply with NFPA 70.

2.6 OUTDOOR, AIR-SOURCE HEAT-PUMP UNITS

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

- 1. Specially designed for use in systems with either all heating or all cooling demands, but not for use in systems with simultaneous heating and cooling.
- 2. Systems shall consist of one unit, or multiple unit modules that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.
- 3. All units installed shall be from the same product development generation.

B. Cabinet:

- 1. Galvanized steel and coated with a corrosion-resistant finish.
 - a. Coating with documented salt spray test performance of 1000 hours according ASTM B117 surface scratch test (SST) procedure.
- 2. Mounting: Manufacturer-designed provisions for field installation.
- 3. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. Compressor and Motor Assembly:

- 1. One or more positive-displacement, direct-drive and hermetically sealed scroll compressor(s) with inverter drive and turndown to 15 percent of rated capacity.

2. Protection: Integral protection against the following:
 - a. High refrigerant pressure.
 - b. Low oil level.
 - c. High oil temperature.
 - d. Thermal and overload.
 - e. Voltage fluctuations.
 - f. Phase failure and phase reversal.
 - g. Short cycling.
3. Speed Control: Variable to automatically maintain refrigerant suction and condensing pressures while varying refrigerant flow to satisfy system cooling and heating loads.
4. Vibration Control: Integral isolation to dampen vibration transmission.
5. Oil management system to ensure safe and proper lubrication over entire operating range.
6. Crankcase heaters with integral control to maintain safe operating temperature.
7. Fusible plug.

D. Condenser Coil Assembly:

1. Plate Fin Coils:
 - a. Casing: Aluminum, galvanized, or stainless steel.
 - b. Fins: Aluminum or copper, mechanically bonded to tubes, with arrangement required by performance.
 - c. Tubes: Copper, of diameter and thickness required by performance.
2. Aluminum Microchannel Coils:
 - a. Series of flat tubes containing a series of multiple, parallel-flow microchannels layered between refrigerant header manifolds.
 - b. Single- or multiple-pass arrangement.
 - c. Construct fins, tubes, and header manifolds of aluminum alloy.
3. Coating: Corrosion resistant.
4. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.

E. Condenser Fan and Motor Assembly:

1. Fan(s): Propeller type.
 - a. Direct-drive arrangement.
 - b. Fabricated from non-ferrous components or ferrous components with corrosion protection finish to match performance indicated for condenser coil.
 - c. Statically and dynamically balanced.
2. Fan Guards: Removable safety guards complying with OSHA regulations. If using metal materials, coat with corrosion-resistant coating to match performance indicated for condenser coil.

3. Motor(s): Brushless dc or electronically commutated with permanently lubricated bearings and rated for outdoor duty.
 4. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
 5. Speed Settings and Control: Variable speed with a speed range of least 75 percent.
 6. Vibration Control: Integral isolation to dampen vibration transmission.
- F. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.
- G. Unit Controls:
1. Enclosure: Manufacturer's standard, and suitable for unprotected outdoor locations.
 2. Factory-Installed Controller: Configurable digital control.
 3. Factory-Installed Sensors:
 - a. Refrigerant suction temperature.
 - b. Refrigerant discharge temperature.
 - c. Outdoor air temperature.
 - d. Refrigerant high pressure.
 - e. Refrigerant low pressure.
 - f. Oil level.
 4. Features and Functions: Self-diagnostics, time delay, auto-restart, fuse protection, auto operation mode, night setback control, equalize run time between multiple same components.
 5. Communication: Network communication with indoor units and other outdoor unit(s).
 6. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 7. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
- H. Unit Electrical:
1. Enclosure: Metal, similar to enclosure, and suitable for unprotected outdoor locations.
 2. Field Connection: Single point connection to power entire unit and integral controls.
 3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
 4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
 5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 6. Raceways: Enclose line voltage wiring in raceways to comply with NFPA 70.
- I. Unit Hardware: Zinc-plated steel, or stainless steel. Coat exposed surfaces with additional corrosion-resistant coating if required to prevent corrosion when exposed to salt spray test for 1000 hours according to ASTM B117.
- J. Unit Piping:
1. Unit Tubing: Copper tubing with brazed joints.

2. Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
3. Field Piping Connections: Manufacturer's standard.
4. Factory Charge: Dehydrated air or nitrogen.
5. Testing: Factory pressure tested and verified to be without leaks.

2.7 SYSTEM CONTROLS

A. General Requirements:

1. Network: Indoor units and outdoor units shall include integral controls and connect through a TIA-485A or manufacturer-selected control network.
2. Network Communication Protocol: Manufacturer proprietary or open control communication between interconnected units.
3. Integration with Building Automation System: ASHRAE 135, BACnet IP and certified by BACnet Testing Lab (BTL), including the following:
 - a. Ethernet connection via RJ-45 connectors and port with transmission at 100 Mbps or higher.
 - b. Integration devices shall be connected to local uninterruptible power supply unit(s) to provide at least 5 minutes of battery backup operation after a power loss.
 - c. Integration shall include **control**.
4. Operator Interface:
 - a. Operators shall interface with system and unit controls through the following:
 - 1) Operator interfaces integral to controllers.
 - 2) Owner-furnished PC connected to central controller(s).
 - 3) Web interface through web browser software.
 - 4) Integration with Building Automation System.
 - b. Users shall be capable of interface with controllers for indoor units control to extent privileges are enabled. Control features available to users shall include the following:
 - 1) On/off control.
 - 2) Temperature set-point adjustment.

B. VRF HVAC System Operator Software for PC:

1. Software offered by VRF HVAC system manufacturer shall provide system operators with ability to monitor and control VRF HVAC system(s) from a single dedicated Owner-furnished PC.
2. Software shall provide operator with a graphic user interface to allow monitoring and control of multiple central controllers from a single device location through point-and-click mouse exchange.
3. Plan views shall show building plans with location of indoor units and identification superimposed on plans.

4. Controls operation mode of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Operation modes available through central controller shall match those operation modes of controllers for indoor units.
5. Schedules operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Schedules daily, weekly, and annual events.
6. Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
7. Optimized start feature to start indoor units before scheduled time to reach temperature set-point at scheduled time based on operating history.
8. Night setback feature to operate indoor units at energy-conserving heating and cooling temperature set-points during unoccupied periods.
9. Supports Multiple Languages: English.
10. Supports Imperial and Metric Temperature Units: Fahrenheit .
11. Displays service notifications and error codes.
12. Monitors and displays up to 3000 item error history and 10000 item operation history for regular reporting and further archiving.
13. Monitors and displays cumulative operating time of indoor units.
14. Able to disable and enable operation of individual controllers for indoor units.
15. Information displayed on individual controllers shall also be available for display.
16. Information displayed for outdoor units, including refrigerant high and low pressures percent capacity.

C. Central Controllers:

1. Centralized control for all indoor and outdoor units from a single central controller location.
 - a. Include multiple interconnected controllers as required.
2. Controls operation mode of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Operation modes available through central controller shall match those operation modes of controllers for indoor units.
3. Schedule operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
 - a. Sets schedule for daily, weekly, and annual events.
 - b. Schedule options available through central controller shall at least include the schedule options of controllers for indoor units.
4. Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
5. Optimized start feature to start indoor units before scheduled time to reach temperature set-point at scheduled time based on operating history.
6. Night setback feature to operate indoor units at energy-conserving heating and cooling temperature set-points during unoccupied periods.
7. Service diagnostics tool.
8. Able to disable and enable operation of individual controllers for indoor units.
9. Information displayed on individual controllers shall also be available for display through central controller.

10. Information displayed for outdoor units, including refrigerant high and low pressures percent capacity.
11. Multiple RJ-45 ports for direct connection to a local PC and an Ethernet network switch.
12. Operator interface through a backlit, high-resolution color display touch panel.

D. Wired Controllers for Indoor Units:

1. Single controller capable of controlling multiple indoor units as group.
2. Auto Timeout Touch Screen LCD: Timeout duration shall be adjustable.
3. Multiple Language: English.
4. Temperature Units: Fahrenheit.
5. On/Off: Turns indoor unit on or off.
6. Hold: Hold operation settings until hold is released.
7. Operation Mode: Cool, Heat, Auto, Dehumidification, Fan Only, and Setback.
8. Temperature Display: 1-degree increments.
9. Temperature Set-Point: Separate set points for Cooling, Heating, and Setback. Adjustable in 1-degree increments between 68 and 75 Fahrenheit.
10. Relative Humidity Display: 1 percent increments.
11. Fan Speed Setting: Select between available options furnished with the unit.
12. Airflow Direction Setting: If applicable to unit, select between available options furnished with the unit.
13. Seven-day programmable operating schedule with up to five events per day. Operations shall include On/Off, Operation Mode, and Temperature Set-Point.
14. Auto Off Timer: Operates unit for an adjustable time duration and then turns unit off.
15. Occupancy detection.
16. Service Notification Display: "Filter" .
17. Service Run Tests: Limit use by service personnel to troubleshoot operation.
18. Error Code Notification Display: Used by service personnel to troubleshoot abnormal operation and equipment failure.
19. User and Service Passwords: Capable of preventing adjustments by unauthorized users.
20. Setting stored in nonvolatile memory to ensure that settings are not lost if power is lost. Battery backup for date and time only.
21. Low-voltage power required for controller shall be powered through non-polar connections to indoor unit.

2.8 SYSTEM REFRIGERANT AND OIL

A. Refrigerant:

1. As required by VRF HVAC system manufacturer for system to comply with performance requirements indicated.
2. ASHRAE 34, Class A1 refrigerant classification.
3. R-410a.

B. Oil:

1. As required by VRF HVAC system manufacturer and to comply with performance requirements indicated.

2.9 SYSTEM CONDENSATE DRAIN PIPING

- A. If more than one material is listed, material selection is Contractor's option.
- B. Copper Tubing:
 - 1. Drawn-Temper Tubing: According to ASTM B88, Type L or Type DWV according to ASTM B306.
 - 2. Wrought-Copper Fittings: ASME B16.22.
 - 3. Wrought-Copper Unions: ASME B16.22.
 - 4. Solder Filler Metals: ASTM B32, lead-free alloys, and water-flushable flux according to ASTM B813.
- C. CPVC plastic pipe according to ASTM F441/F441M, Schedule 40, with socket-type pipe fittings according to ASTM F438 and solvent cement according to ASTM F493.
- D. PVC plastic pipe according to ASTM D1785, Schedule 40, with socket-type pipe fittings according to ASTM D2466 and solvent cement according to ASTM D2564, primer according to ASTM F656.

2.10 SYSTEM REFRIGERANT PIPING

- A. Comply with requirements in Section 232300 "Refrigerant Piping" for system piping requirements.
- B. Refrigerant Piping:
 - 1. Copper Tube: ASTM B280, Type ACR.
 - 2. Wrought-Copper Fittings: ASME B16.22.
 - 3. Brazing Filler Metals: AWS A5.8/A5.8M.
- C. Refrigerant Tubing Kits:
 - 1. Furnished by VRF HVAC system manufacturer.
 - 2. Factory-rolled and -bundled, soft-copper tubing with tubing termination fittings at each end.
 - 3. Standard one-piece length for connecting to indoor units.
 - 4. Pre-insulated with flexible elastomeric insulation of thickness to comply with governing energy code and sufficient to eliminate condensation.
 - 5. Factory Charge: Dehydrated air or nitrogen.
- D. Divided-Flow Specialty Fittings: Where required by VRF HVAC system manufacturer for proper system operation, VRF HVAC system manufacturer shall furnish specialty fittings with identification and instructions for proper installation by Installer.
- E. Refrigerant Isolation Ball Valves:

1. Description: Uni-body full port design, rated for maximum system temperature and pressure, and factory tested under pressure to ensure tight shutoff. Designed for valve operation without removing seal cap.
2. Seals: Compatible with system refrigerant and oil. Seal service life of at least 20 years.
3. Valve Connections: Flare or sweat depending on size.

2.11 METAL HANGERS AND SUPPORTS

A. Copper Tube Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized or copper-coated steel.

B. Plastic Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, galvanized-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel.

2.12 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Business.
 - b. Cooper B-line; brand of Eaton, Electrical Sector.
 - c. Flex-Strut Inc.
 - d. G-Strut.
 - e. Haydon Corporation.
 - f. MIRO Industries.
 - g. Unistrut; Atkore International.
 - h. Wesanco, Inc.
3. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
4. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
5. Channels: Continuous slotted carbon-steel channel with intumed lips.
6. Channel Width: Selected for applicable load criteria.
7. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.

8. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel for use indoors and of stainless steel for use outdoors.
9. Metallic Coating for Use Indoors: No coating.
10. Plastic Coating for Use Outdoors: PVC.

2.13 FASTENER SYSTEMS

- A. Powder-Actuated Fasteners: Threaded, zinc-coated steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- B. Mechanical-Expansion Anchors: Insert-wedge-type anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
 1. Indoor Applications: Zinc-coated or stainless steel.
 2. Outdoor Applications: Stainless steel.

2.14 OUTDOOR EQUIPMENT STANDS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. MIRO Industries.
 2. RectorSeal HVAC; a CSW Industrials Company.
 3. Rooftop Support Systems; Eberl Iron Works, Inc.
- C. Description: Individual foot supports with elevated adjustable channel cross bars and clamps/fasteners/bolts for ground or roof-supported outdoor equipment components, without roof membrane penetration, in a prefabricated system that can be modularly assembled on-site.
- D. Foot Material: Rubber or polypropylene.
- E. Rails Material: Hot-dip galvanized carbon steel.
- F. Wind/Sliding Load Resistance: Up to 100 mph minimum.

2.15 MISCELLANEOUS SUPPORT MATERIALS

- A. Grout: ASTM C1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 1. Properties: Nonstaining, noncorrosive, and nongaseous.

2. Design Mix: 5000-psi, 28-day compressive strength.

B. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; galvanized.

C. Threaded Rods: Continuously threaded. Zinc-plated steel or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar material as rods.

2.16 PIPING AND TUBING INSULATION

A. Comply with requirements in Section 230719 "HVAC Piping Insulation" for system piping insulation requirements.

B. Condensate Drain Piping and Tubing Insulation and Jacket Requirements:

1. Flexible Elastomeric Insulation:

- a. Closed-cell, sponge- or expanded-rubber materials, complying with ASTM C534, Type I for tubular materials.
- b. Indoors: 1/2 inch thick.
- c. Outdoors: 3/4 inch thick.

2. Field-Applied Jacket:

- a. Concealed: None required.
- b. Indoors, Exposed to View: None required.
- c. Outdoors, Exposed to View: Aluminum, smooth, 0.020 inch thick.

C. Refrigerant Tubing Insulation and Jacket Requirements:

1. Flexible Elastomeric Insulation:

- a. Closed-cell, sponge- or expanded-rubber materials, complying with ASTM C534, Type I for tubular materials.
- b. Indoors: 1 inch thick.
- c. Outdoors: 1 inch thick.

2. Field-Applied Jacket:

- a. Concealed: None required.
- b. Indoors, Exposed to View: None required.
- c. Outdoors, Exposed to View: Aluminum, smooth, 0.020 inch thick.

D. Flexible Elastomeric Insulation Adhesive: Comply with MIL-A-24179A, Type II, Class I.

E. PVC Jacket Adhesive: Compatible with PVC jacket.

F. Metal Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.

2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: Aluminum.

2.17 SYSTEM CONTROL CABLE

A. Cable Rating: Listed and labeled for application according to NFPA 70.

1. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262, by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.
 - a. Flame Travel Distance: 60 inches or less.
 - b. Peak Optical Smoke Density: 0.5 or less.
 - c. Average Optical Smoke Density: 0.15 or less.
2. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.
3. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

B. Low-Voltage Control Cabling:

1. Paired Cable: NFPA 70, Type CMG.
 - a. One pair, twisted, No. 16 AWG, stranded (19x29) or No. 18 AWG, stranded (19x30) tinned-copper conductors as required by VRF HVAC system manufacturer.
 - b. PVC insulation.
 - c. Braided or foil shielded.
 - d. PVC jacket.
 - e. Flame Resistance: Comply with UL 1685.
2. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
 - a. One pair, twisted, No. 16 AWG, stranded (19x29) or No. 18 AWG, stranded (19x30) tinned-copper conductors as required by VRF HVAC system manufacturer.
 - b. PVC insulation.
 - c. Braided or foil shielded.
 - d. PVC jacket.
 - e. NFPA 262 includes the standard flame-resistance test criteria in common use for cables and conductors.
 - f. Flame Resistance: Comply with NFPA 262.

C. TIA-485A Network Cabling:

1. Standard Cable: NFPA 70, Type CMG.

- a. Paired, [**one pair**] [**two pairs**], twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
 - b. PVC insulation.
 - c. Unshielded.
 - d. PVC jacket.
 - e. Flame Resistance: Comply with UL 1685.
2. Plenum-Rated Cable: NFPA 70, Type CMP.
- a. Paired, one pair, No. 22 AWG, stranded (7x30) tinned-copper conductors.
 - b. Fluorinated ethylene propylene insulation.
 - c. Unshielded.
 - d. Fluorinated ethylene propylene jacket.
 - e. NFPA 262 includes the standard flame-resistance test criteria in common use for cables and conductors.
 - f. Flame Resistance: NFPA 262.

D. Ethernet Network Cabling: TIA-568-C.2 Category 6 cable with RJ-45 connectors.

1. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of category cable indicated.
2. Conductors: 100-ohm, 23 AWG solid copper.
3. Shielding: Unshielded twisted pairs (UTP).
4. Cable Rating: By application.
5. Jacket: White thermoplastic.

E. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for control wiring and cable raceways.

2.18 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B209.

E. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.

F. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a 3000-hour salt-spray test according to ASTM B117.

1. Standards:
 - a. ASTM B117 for salt spray.
 - b. ASTM D2794 for minimum impact resistance of 100 in-lb.
 - c. ASTM B3359 for cross-hatch adhesion of 5B.
2. Application: Immersion.
3. Thickness: 1 mil.
4. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.19 SOURCE QUALITY CONTROL

- A. Factory Tests: Test and inspect factory-assembled equipment.
- B. Equipment will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports for historical record. Submit reports only if requested.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine products before installation. Reject products that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for piping and tubing to verify actual locations of connections before equipment installation.
- D. Examine roughing-in for ductwork to verify actual locations of connections before equipment installation.
- E. Examine roughing-in for wiring and conduit to verify actual locations of connections before equipment installation.
- F. Examine walls, floors, roofs, and outdoor pads for suitable conditions where equipment will be installed.
- G. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- H. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EQUIPMENT INSTALLATION, GENERAL

- A. Clearance:
 - 1. Maintain manufacturer's recommended clearances for service and maintenance.
 - 2. Maintain clearances required by governing code.
- B. Loose Components: Install components, devices, and accessories furnished by manufacturer, with equipment, that are not factory mounted.
 - 1. Loose components shall be installed by manufacturer's service representative or system Installer under supervision of manufacturer's service representative.
- C. Equipment Restraint Installation: Install equipment with seismic-restraint device. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

3.3 INSTALLATION OF INDOOR UNITS

- A. Install units to be level and plumb while providing a neat and finished appearance.
- B. Unless otherwise required by VRF HVAC system manufacturer, support ceiling-mounted units from structure above using threaded rods; minimum rod size of 3/8 inch.
- C. Adjust supports of exposed and recessed units to draw units tight to adjoining surfaces.
- D. Protect finished surfaces of ceilings, floors, and walls that come in direct contact with units. Refinish or replaced damaged areas after units are installed.
- E. In rooms with ceilings, conceal piping and tubing, controls, and electrical power serving units above ceilings.
- F. In rooms without ceiling, arrange piping and tubing, controls, and electrical power serving units to provide a neat and finished appearance.
- G. Provide lateral bracing if needed to limit movement of suspended units to not more than 0.25 inch.
- H. For floor- and wall-mounted units that are exposed, conceal piping and tubing, controls, and electrical power serving units within walls.
- I. Floor-mounted units located in mechanical rooms.
- J. Install floor-mounted units on support structure indicated on Drawings.
- K. Install floor-mounted units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
- L. Attachment: Install hardware for proper attachment to supported equipment.

- M. Grouting: Place grout under equipment supports and make bearing surface smooth.

3.4 INSTALLATION OF OUTDOOR UNITS

- A. Install units to be level and plumb while providing a neat and finished appearance.
- B. Install outdoor units on support structures indicated on Drawings.
- C. Pad-Mounted Installations: Install outdoor units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 1. Attachment: Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 2. Grouting: Place grout under equipment supports and make bearing surface smooth.
- D. Roof-Mounted Installations: Install outdoor units on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, stainless-steel fasteners.

3.5 GENERAL REQUIREMENTS FOR PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping and tubing systems. Install piping and tubing as indicated unless deviations to layout are approved on coordination drawings.
- B. Install piping and tubing in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping and tubing at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping and tubing above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping and tubing to permit valve servicing.
- F. Install piping and tubing at indicated slopes.
- G. Install piping and tubing free of sags.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping and tubing to allow application of insulation.
- J. Install groups of pipes and tubing parallel to each other, spaced to permit applying insulation with service access between insulated piping and tubing.

- K. Install sleeves for piping and tubing penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- L. Install escutcheons for piping and tubing penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.6 INSTALLATION OF SYSTEM CONDENSATE DRAIN PIPING

A. General Requirements for Drain Piping and Tubing:

- 1. Install a union in piping at each threaded unit connection.
- 2. Install an adjustable stainless-steel hose clamp with adjustable gear operator on unit hose connections. Tighten clamp to provide a leak-free installation.
- 3. If required for unit installation, provide a trap assembly in drain piping to prevent air circulated through unit from passing through drain piping. Comply with more stringent of the following:
 - a. Details indicated on Drawings.
 - b. Manufacturer's requirements.
 - c. Governing codes.
 - d. In the absence of requirements, comply with requirements of ASHRAE handbooks.
- 4. Extend drain piping from units with drain connections to drain receptors as indicated on Drawings. If not indicated on Drawings, terminate drain connection at nearest accessible location that is not exposed to view by occupants.
- 5. Provide each 90-degree change in direction with a Y- or T-fitting. Install a threaded plug connection in the dormant side of fitting or future use as a service cleanout.

B. Gravity Drains:

- 1. Slope piping from unit connection toward drain termination at a constant slope of not less than one percent.

C. Pumped Drains:

- 1. If unit condensate pump or lift mechanism is not included with an integral check valve, install a full-size check valve in each branch pipe near unit connection to prevent backflow into unit.

3.7 INSTALLATION OF REFRIGERANT PIPING

A. Refrigerant Tubing Kits:

- 1. Unroll and straighten tubing to suit installation. Deviations in straightness of exposed tubing shall be unnoticeable to observer.

2. Support tubing using hangers and supports indicated at intervals not to exceed 5 feet. Minimum rod size, 1/4 inch.
 3. Prepare tubing ends and make mating connections to provide a pressure tight and leak-free installation.
- B. Install refrigerant piping according to ASHRAE 15 and governing codes.
- C. Select system components with pressure rating equal to or greater than system operating pressure.
- D. Install piping as short and direct as possible, with a minimum number of joints and fittings.
- E. Arrange piping to allow inspection and service of equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 083113 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.
- F. Install refrigerant piping and tubing in protective conduit where installed belowground.
- G. Install refrigerant piping and tubing in rigid or flexible conduit in locations where exposed to mechanical damage.
- H. Unless otherwise required by VRF HVAC system manufacturer, slope refrigerant piping and tubing as follows:
1. Install horizontal hot-gas discharge piping and tubing with a uniform slope downward away from compressor.
 2. Install horizontal suction lines with a uniform slope downward to compressor.
 3. Install traps to entrain oil in vertical runs.
 4. Liquid lines may be installed level.
- I. When brazing, remove or protect components that could be damaged by heat.
- J. Before installation, clean piping, tubing, and fittings to cleanliness level required by VRF HVAC system manufacturer.
- K. Joint Construction:
1. Ream ends of tubes and remove burrs.
 2. Remove scale, slag, dirt, and debris from inside and outside of tube and fittings before assembly.
 3. Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.
 - a. Use Type BCuP (copper-phosphorus) alloy for joining copper fittings with copper tubing.
 - b. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze.

3.8 INSTALLATION OF METAL HANGERS AND SUPPORTS

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- B. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
- C. Comply with MFMA-103 for metal framing system selections and applications that are not specified.
- D. Fastener System Installation:
 - 1. Install powder-actuated fasteners, for use in lightweight concrete or concrete slabs less than 4 inches thick, in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 - 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
 - 3. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.
- E. Pipe Stand Installation:
 - 1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 - 2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.
- F. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- G. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- H. Install lateral bracing with pipe hangers and supports to prevent swaying.
- I. Install building attachments within concrete slabs or attach to structural steel.
 - 1. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- J. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- K. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

L. Piping and Tubing Insulation:

1. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
2. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.

M. Horizontal-Piping Hangers and Supports: Install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
3. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
4. Multiple horizontal pipes located indoors may use metal framing systems with split clamp attachment for each pipe in lieu of individual clevis hangers.
5. Pipe stands for horizontal pipes located outdoors.
6. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
7. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

N. Horizontal Piping Hanger Spacing and Rod Size: Install hangers for drawn-temper copper piping with the following maximum horizontal spacing and minimum rod sizes:

1. Sizes through NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/4: Maximum span, 7 feet; minimum rod size, 3/8 inch.
4. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
5. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
6. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
7. NPS 3 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch.

O. Plastic Pipe Hanger and Support Spacing:

1. Space hangers and supports according to pipe manufacturer's written instructions for service conditions.
2. Maximum spacing, 5 feet; minimum rod size, 1/4 inch.

P. Vertical-Piping Clamps: Install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8).
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): If longer ends are required for riser clamps.

Q. Support vertical runs at roof, at each floor, and at midpoint intervals between floors, not to exceed 5 feet.

- R. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified.
- S. Use hangers, supports, and attachments with galvanized coatings unless otherwise indicated.
- T. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- U. Trim excess length of continuous-thread hanger and support rods to 1 inch.
- V. Hanger-Rod Attachments: Install the following types:
 - 1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
 - 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
 - 3. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 - 4. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.
- W. Building Attachments: Install the following types:
 - 1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 - 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
 - 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 - 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 - 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 - 6. C-Clamps (MSS Type 23): For structural shapes.
 - 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 - 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 - 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 - 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 - 11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 - 12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
 - 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 - 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 - 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

3.9 INSTALLATION OF PIPING AND TUBING INSULATION

- A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated. Installation to maintain a continuous vapor barrier.
- B. Insulation Installation on Pipe Fittings and Elbows:
 - 1. Install mitered sections of pipe insulation.
 - 2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C. Insulation Installation on Valves and Pipe Specialties:
 - 1. Install preformed valve covers manufactured of same material as pipe insulation when available.
 - 2. When preformed valve covers are unavailable, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - 3. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- D. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.
 - 1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- E. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.10 INSTALLATION OF DUCT, ACCESSORIES, AND AIR OUTLETS

- A. Where installing ductwork adjacent to equipment, allow space for service and maintenance.
- B. Comply with requirements for metal ducts specified in Section 233113 "Metal Ducts."
- C. Comply with requirements for nonmetal ducts specified in Section 233116 "Nonmetal Ducts."
- D. Comply with requirements for air duct accessories specified in Section 233300 "Air Duct Accessories."
- E. Comply with requirements for flexible ducts specified in Section 233346 "Flexible Ducts."
- F. Comply with requirements for air diffusers specified in Section 233713.13 "Air Diffusers."

- G. Comply with requirements for registers and grilles specified in Section 233713.23 "Registers and Grilles."

3.11 ELECTRICAL INSTALLATION

- A. Comply with requirements indicated on Drawings and in applicable Division 26 Sections.
- B. To extent electrical power is required for system equipment, components, and controls, and is not indicated on Drawings and addressed in the Specifications, the design for such electrical power shall be delegated to VRF HVAC system provider.
 - 1. Delegated design of electrical power to equipment, components and controls, and associated installation shall be included at no additional cost to Owner.
- C. Connect field electrical power source to each separate electrical device requiring field electrical power. Coordinate termination point and connection type with Installer.
- D. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.
- E. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding connections.
- F. Install nameplate or acrylic label with self-adhesive back for each electrical connection indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated phenolic layers of black with engraved white letters. Letters at least 1/2 inch high.
 - 2. Locate nameplate or label where easily visible.
- G. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for raceway selection and installation requirements for boxes, conduits, and wireways as supplemented or revised in this Section.
 - 1. Outlet boxes shall be no smaller than 2 inches wide, 3 inches high, and 2-1/2 inches deep.
 - 2. Outlet boxes for cables shall be no smaller than 4 inches square by 1-1/2 inches deep with extension ring sized to bring edge of ring to within 1/8 inch of the finished wall surface.
 - 3. Flexible metal conduit shall not be used.
- H. Comply with TIA-569-D for pull-box sizing and length of conduit and number of bends between pull points.
- I. Install manufactured conduit sweeps and long-radius elbows if possible.
- J. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

3.12 SOFTWARE

A. Cybersecurity:

1. Software:

- a. Coordinate security requirements with IT department.
- b. Ensure that latest stable software release is installed and properly operating.
- c. Disable or change default passwords to password using a combination of uppercase and lower letters, numbers, and symbols at least eight characters in length. Record passwords and turn over to party responsible for system operation and administration.

2. Hardware:

- a. Coordinate location and access requirements with IT department.
- b. Enable highest level of wireless encryption that is compatible with Owner's ICT network.
- c. Disable dual network connections.

3.13 INSTALLATION OF SYSTEM CONTROL CABLE

A. Comply with NECA 1.

B. Installation Method:

1. Install cables in raceways except as follows:

- a. Within equipment and associated control enclosures.
- b. In accessible ceiling spaces where open cable installation method may be used.
- c. In gypsum board partitions where cable may be enclosed within wall cavity.

2. Conceal raceway and cables except in unfinished spaces.

C. General Requirements for Cabling:

1. Comply with TIA-568-C Series of standards.
2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems."
3. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
4. Cables may not be spliced and shall be continuous from terminal to terminal. Do not splice cable.
5. Cables serving a common system may be grouped in a common raceway. Install control cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
6. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.

7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Install lacing bars and distribution spools.
8. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.
9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Monitor cable pull tensions.
11. Support: Do not allow cables to lie on removable ceiling tiles or access panels.
12. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.
13. Provide strain relief.
14. Keep runs short. Allow extra length for connecting to terminals.
15. Do not bend cables in a radius less than 10 times the cable OD.
16. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
17. Ground wire shall be copper, and grounding methods shall comply with IEEE C2. Demonstrate ground resistance.

D. Balanced Twisted-Pair Cable Installation:

1. Comply with TIA-568-C.2.
2. Do not untwist balanced twisted-pair cables more than 1/2 inch at the point of termination to maintain cable geometry.

E. Open-Cable Installation:

1. Suspend copper cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 30 inches apart.
2. Cable shall not be run through or on structural members or in contact with pipes, ducts, or other potentially damaging items. Do not run cables between structural members and corrugated panels.

F. Separation from EMI Sources: Comply with BICSI TDMM and TIA-569-D recommendations for separating unshielded cable from potential EMI sources including electrical power wiring and equipment.

3.14 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-D, Annex A, "Firestopping."
- C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.15 GROUNDING INSTALLATION

- A. For data communication wiring, comply with TIA-607-B and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.
- B. For low-voltage control cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.16 IDENTIFICATION

- A. Identify system equipment, piping, tubing, and valves. Comply with requirements for identification specified in Section 230553 "Identification for HVAC Piping and Equipment."
- B. Identify system electrical components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
 - 1. Identify each control cable on each end and at each terminal with a number-coded identification tag. Each cable shall have a unique tag.

3.17 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage VRF HVAC system manufacturer's service representative to advise and assist installers; witness testing; and observe and inspect components, assemblies, and equipment installations, including controls and connections.
 - 1. Field service shall be performed by a factory-trained and -authorized service representative of VRF HVAC system manufacturer whose primary job responsibilities are to provide direct technical support of its products.
 - a. Additional factory-authorized representatives may assist with completion of certain activities only if supervised by manufacturer's employee. A factory-authorized representative shall not provide assistance without manufacturer's employee supervision.
 - 2. Manufacturer shall provide on-site visits during the course of construction at installation milestones indicated. System Installer shall coordinate each visit in advance to give manufacturer sufficient notice to plan the visit.
 - a. First Visit: Kick-off meeting.
 - b. Second Visit: At approximately 25 percent completion of system(s).
 - c. Third Visit: At approximately 50 percent completion of system(s).
 - d. Fourth Visit: At approximately 75 percent completion of system(s).
 - e. Fifth Visit: Final inspection before system startup.
 - 3. Kick-off Meeting:

- a. Meeting shall include system Installer and other related trades with sole purpose of reviewing VRF HVAC system installation requirements and close coordination required to make a successful installation.
 - b. Meeting shall be held at Project site and scheduled at a mutually agreed to time that occurs before the start of any part of system installation.
 - c. Meeting shall cover the following as a minimum requirement:
 - 1) Review of latest issue of Contract Documents, Drawings, and Specifications, relevant to VRF HVAC systems.
 - 2) Manufacturer's installation requirements specific to systems being installed.
 - 3) Review of all relevant VRF HVAC system submittals, including delegated-design submittals.
 - 4) Required field activities related installation of VRF HVAC system.
 - 5) Project team communication protocol, contact information, and exchange of responsibilities for each party involved, including manufacturer, supplier, system Installer, and other related trades.
4. Site Visits: Activities for each site visit shall include the following:
- a. Meet with VRF HVAC system Installer to discuss field activities, issues, and suggested methods to result in a successful installation.
 - b. Offer technical support to Installer and related trades as related to VRF system(s) being installed.
 - c. Review progress of VRF HVAC system(s) installation for strict compliance with manufacturer's requirements.
 - d. Advise and if necessary assist Installer with updating related refrigerant calculations and system documentation.
 - e. Issue a report for each visit, documenting the visit.
 - 1) Report to include name and contact information of individual making the visit.
 - 2) Date(s) and time frames while on-site.
 - 3) Names and contact information of people meeting with while on-site.
 - 4) Clearly identify and list each separate issue that requires resolution. For each issue, provide a unique identification number, relevant importance, specific location or equipment identification, description of issue, recommended corrective action, and follow-up requirements needed. Include a digital photo for clarification if deemed to be beneficial.
5. Final Inspection before Startup:
- a. Before inspection, Installer to provide written request to manufacturer stating the system is fully installed according manufacturer's requirements and ready for final inspection.
 - b. All system equipment and operating components shall be inspected. If components are inaccessible for inspection, they shall be made accessible before the final inspection can be completed.
 - c. Manufacturer shall provide a comprehensive inspection of all equipment and each operating component that comprise the complete system(s). Inspection shall follow a detailed checklist specific to each equipment and operating component.

- d. Inspection reports for indoor units shall include, but not be limited to, the following:
- 1) Unit designation on Drawings.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Network address, if applicable.
 - 5) Each equipment setting.
 - 6) Mounting, supports, and restraints properly installed.
 - 7) Proper service clearance provided.
 - 8) Wiring and power connections correct.
 - 9) Line-voltage reading(s) within acceptable range.
 - 10) Wiring and controls connections correct.
 - 11) Low-voltage reading(s) within an acceptable range.
 - 12) Controller type and model controlling unit.
 - 13) Controller location.
 - 14) Temperature settings and readings within an acceptable range.
 - 15) Humidity settings and readings within an acceptable range.
 - 16) Condensate removal acceptable.
 - 17) Fan settings and readings within an acceptable range.
 - 18) Unit airflow direction within an acceptable range.
 - 19) If applicable, fan external static pressure setting.
 - 20) Filter type and condition acceptable.
 - 21) Noise level within an acceptable range.
 - 22) Refrigerant piping properly connected and insulated.
 - 23) Condensate drain piping properly connected and insulated.
 - 24) If applicable, ductwork properly connected.
 - 25) If applicable, external interlocks properly connected.
 - 26) Remarks.
- e. Inspection reports for outdoor units shall include, but not be limited to, the following:
- 1) Unit designation on Drawings.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Network address, if applicable.
 - 5) Each equipment setting.
 - 6) Mounting, supports, and restraints properly installed.
 - 7) Proper service clearance provided.
 - 8) Wiring and power connections correct.
 - 9) Line-voltage reading(s) within acceptable range.
 - 10) Wiring and controls connections correct.
 - 11) Low-voltage reading(s) within an acceptable range.
 - 12) Condensate removal acceptable.
 - 13) Noise level within an acceptable range.
 - 14) Refrigerant piping properly connected and insulated.
 - 15) Condensate drain piping properly connected and insulated.
 - 16) Remarks.

- f. Inspection reports for indoor, dedicated outdoor air ventilation units shall include, but not be limited to, the following:
- 1) Unit designation on Drawings.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Network address, if applicable.
 - 5) Each equipment setting.
 - 6) Mounting, supports, and restraints properly installed.
 - 7) Proper service clearance provided.
 - 8) Wiring and power connections correct.
 - 9) Line-voltage reading(s) within acceptable range.
 - 10) Wiring and controls connections correct.
 - 11) Low-voltage reading(s) within an acceptable range.
 - 12) Controller type and model controlling unit.
 - 13) Controller location.
 - 14) Temperature settings and readings within an acceptable range.
 - 15) Humidity settings and readings within an acceptable range.
 - 16) Condensate removal acceptable.
 - 17) Fan settings and readings within an acceptable range.
 - 18) Fan external static pressure setting.
 - 19) Filter type and condition acceptable.
 - 20) Noise level within an acceptable range.
 - 21) Refrigerant piping properly connected and insulated.
 - 22) Condensate drain piping properly connected and insulated.
 - 23) Automatic dampers properly installed and operating.
 - 24) Ductwork properly connected.
 - 25) If applicable, external interlocks properly connected.
 - 26) Remarks.
- g. Inspection reports for energy recovery ventilators shall include, but not be limited to, the following:
- 1) Unit designation on Drawings.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Network address, if applicable.
 - 5) Each equipment setting.
 - 6) Mounting, supports, and restraints properly installed.
 - 7) Proper service clearance provided.
 - 8) Wiring and power connections correct.
 - 9) Line-voltage reading(s) within acceptable range.
 - 10) Wiring and controls connections correct.
 - 11) Low-voltage reading(s) within an acceptable range.
 - 12) Controller type and model controlling unit.
 - 13) Controller location.
 - 14) Temperature settings and readings within an acceptable range.
 - 15) Humidity readings.
 - 16) Condensate removal acceptable.
 - 17) Fan settings and readings within an acceptable range.

- 18) Fan external static pressure setting.
- 19) Filter type and condition acceptable.
- 20) Noise level within an acceptable range.
- 21) Automatic dampers properly installed and operating.
- 22) Ductwork properly connected.
- 23) If applicable, external interlocks properly connected.
- 24) Remarks.

h. Inspection reports for hydronic units shall include, but not be limited to, the following:

- 1) Unit designation on Drawings.
- 2) Manufacturer model number.
- 3) Serial number.
- 4) Network address, if applicable.
- 5) Each equipment setting.
- 6) Mounting, supports, and restraints properly installed.
- 7) Proper service clearance provided.
- 8) Wiring and power connections correct.
- 9) Line-voltage reading(s) within acceptable range.
- 10) Wiring and controls connections correct.
- 11) Low-voltage reading(s) within an acceptable range.
- 12) Controller type and model controlling unit.
- 13) Controller location.
- 14) Temperature settings and readings within an acceptable range.
- 15) Condensate removal acceptable.
- 16) Noise level within an acceptable range.
- 17) Refrigerant piping properly connected and insulated.
- 18) Hydronic piping properly connected and insulated.
- 19) Proof of water flow checked for proper operation.
- 20) Condensate drain piping properly connected and insulated.
- 21) If applicable, external interlocks properly connected.
- 22) Remarks.

- i. Installer shall provide manufacturer with the requested documentation and technical support during inspection.
- j. Installer shall correct observed deficiencies found by the inspection.
- k. Upon completing the on-site inspection, manufacturer shall provide a written report with complete documentation describing each inspection step, the result, and any corrective action required.
- l. If corrective action is required by Installer that cannot be completed during the same visit, provide additional visits, as required, until deficiencies are resolved and systems are deemed ready for startup.
- m. Final report shall indicate the system(s) inspected are installed according to manufacturer's requirements and are ready for startup.

B. Perform the following tests and inspections with the assistance of manufacturer's service representative:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Refrigerant Tubing Positive Pressure Testing:

1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
2. After completion of tubing installation, pressurize tubing systems to a test pressure of not less than 1.2 times VRF HVAC system operating pressure, but not less than 600 psig, using dry nitrogen.
3. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of 24 hours. Allowance for pressure changes attributed to changes in ambient temperature are acceptable.
4. Prepare test report to record the following information for each test:
 - a. Name of person starting test, company name, phone number, and e-mail address.
 - b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
 - c. Detailed description of extent of tubing tested.
 - d. Date and time at start of test.
 - e. Test pressure at start of test.
 - f. Outdoor temperature at start of test.
 - g. Name of person ending test, company name, phone number, and e-mail address.
 - h. Date and time at end of test.
 - i. Test pressure at end of test.
 - j. Outdoor temperature at end of test.
 - k. Remarks:
5. Submit test reports for Project record.

D. Refrigerant Tubing Evacuation Testing:

1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
2. After completion of tubing positive-pressure testing, evacuate tubing systems to a pressure of 500 microns.
3. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of one hour(s) with no change.
4. Prepare test report to record the following information for each test:
 - a. Name of person starting test, company name, phone number, and e-mail address.
 - b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
 - c. Detailed description of extent of tubing tested.

- d. Date and time at start of test.
 - e. Test pressure at start of test.
 - f. Outdoor temperature at start of test.
 - g. Name of person ending test, company name, phone number, and e-mail address.
 - h. Date and time at end of test.
 - i. Test pressure at end of test.
 - j. Outdoor temperature at end of test.
 - k. Remarks:
5. Submit test reports for Project record.
 6. Upon successful completion of evacuation testing, system shall be charged with refrigerant.
- E. System Refrigerant Charge:
1. Using information collected from the refrigerant tubing evacuation testing, system Installer shall consult variable refrigerant system manufacturer to determine the correct system refrigerant charge.
 2. Installer shall charge system following VRF HVAC system manufacturer's written instructions.
 3. System refrigerant charging shall be witnessed by system manufacturer's representative.
 4. Total refrigerant charge shall be recorded and permanently displayed at the system's outdoor unit.
- F. Products will be considered defective if they do not pass tests and inspections.
- G. Prepare test and inspection reports.

3.18 STARTUP SERVICE

- A. Engage a VRF HVAC system manufacturer's service representative to perform system(s) startup service.
1. Service representative shall be a factory-trained and -authorized service representative of VRF HVAC system manufacturer.
 2. Complete startup service of each separate system.
 3. Complete system startup service according to manufacturer's written instructions.
- B. Startup checks shall include, but not be limited to, the following:
1. Check control communications of equipment and each operating component in system(s).
 2. Check each indoor unit's response to demand for cooling and heating.
 3. Check each indoor unit's response to changes in airflow settings.
 4. Check each indoor unit and outdoor unit for proper condensate removal.
 5. Check sound levels of each indoor unit.
- C. Installer shall accompany manufacturer's service representative during startup service and provide manufacturer's service representative with requested documentation and technical support during startup service.

1. Installer shall correct deficiencies found during startup service for reverification.

D. System Operation Report:

1. After completion of startup service, manufacturer shall issue a report for each separate system.
2. Report shall include complete documentation describing each startup check, the result, and any corrective action required.
3. Manufacturer shall electronically record not less than two hours of continuous operation of each system and submit with report for historical reference.
 - a. All available system operating parameters shall be included in the information submitted.

E. Witness:

1. Invite Architect Owner and Commissioning Agent to witness startup service procedures.
2. Provide written notice not less than 20 business days before start of startup service.

3.19 ADJUSTING

- A. Adjust equipment and components to function smoothly, and lubricate as recommended by manufacturer.
- B. Adjust initial temperature and humidity set points. Adjust initial airflow settings and discharge airflow patterns.
- C. Set field-adjustable switches and circuit-breaker trip ranges according to VRF HVAC system manufacturer's written instructions, and as indicated.
- D. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.20 PROTECTION

- A. Protect products from moisture and water damage. Remove and replace products that are wet, moisture damaged, or mold damaged.
- B. Protect equipment from physical damage. Replace equipment with physical damage that cannot be repaired to new condition. Observable surface imperfections shall be grounds for removal and replacement.
- C. Protect equipment from electrical damage. Replace equipment suffering electrical damage.
- D. Cover and seal openings of equipment to keep inside of equipment clean. Do not remove covers until finish work is complete.

3.21 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of system Installer who are manufacturer's authorized service representative. Include two service visits for preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper equipment and system operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.22 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.
- B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
 - 1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.23 DEMONSTRATION

- A. Engage a VRF HVAC system manufacturer's factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain entire system.
- B. Instructor:
 - 1. Instructor shall be factory trained and certified by VRF HVAC system manufacturer with current training on the system(s), equipment, and controls that are installed.
 - 2. Instructor's credentials shall be submitted for review by Architect before scheduling training.
 - 3. Instructor(s) primary job responsibility shall be Owner training.
 - 4. Instructor(s) shall have not less than three years of training experience with VRF HVAC system manufacturer and past training experience on at least three projects of comparable size and complexity.
- C. Schedule and Duration:
 - 1. Schedule training with Owner at least 20 business days before first training session.
 - 2. Training shall occur before Owner occupancy.
 - 3. Training shall be held at mutually agreed date and time during normal business hours.
 - 4. Each training day shall not exceed eight hours of training. Daily training schedule shall allow time for one-hour lunch period and 15-minute break after every two hours of training.
 - 5. Perform not less than eight total hours of training.

- D. Location: Owner shall provide a suitable on-site location to host classroom training.
- E. Training Attendees: Assume three people.
- F. Training Attendance: For record purposes, document training attendees at the start of each new training session. Record attendee's name, signature, phone number, and e-mail address.
- G. Training Format: Individual training modules shall include classroom training followed by hands-on field demonstration and training.
- H. Training Materials: Provide training materials in electronic format to each attendee.
 - 1. Include instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
 - 2. Video record each classroom training session and submit an electronic copy to Owner before requesting Owner acceptance of training.
- I. Acceptance: Obtain Architect or Owner written acceptance that training is complete and requirements indicated have been satisfied.

END OF SECTION 238129

Special Specification RMA10

Section 220000

Floor Drain/Trench Drain/Wall Clean Out/Hose Bibb/Water hammer Arrestors/Interceptor/Water Closet/Lavatory/Sink/Janitor Sink/Drinking Fountain/Ice Maker Box/Eyewash/Shower/Hot Water Tank/Instantaneous Tankless Water Heater/ Fire Sprinkler System/4" Schedule 40 PVC Piping/4" Schedule 40 PVC Fittings/2" Type K Copper Piping/2" Valves and Fittings

SECTION 220000 - PLUMBING

PART 1 - GENERAL

1.1 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, and other Division Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Plumbing systems including related excavation, bedding, backfilling, piping, fittings, valves, hangers and supports, controls, painting, insulation, plumbing fixtures and trim, and plumbing specialties and equipment; cutting and patching of floors, walls and pavement; and all appurtenant and incidental work to complete and provide operable systems as shown on the drawings and specified herein.
- B. Fees and permits to be obtained and paid for by the Contractor installing that portion of the work.
- C. Provide "Record" drawings after completion of project.

1.3 QUALITY ASSURANCE

- A. Persons performing plumbing work shall have a current Texas State Plumbing License.
- B. Persons performing electrical work shall have a current Texas State Electricians License.
- C. Welding Materials and Procedures. Conform to ASME Code or AWS 10.12.
- D. Welders Certification. Employ certified welders conforming to ANSI/ASME Sec. 9.
- E. Manufacturer's model numbers listed under the acceptable manufacturers and models are provided to indicate the basic product series required. In addition, features listed in the product description shall be included whether or not included with the listed model number.
- F. Pipe sizes, as shown on the Drawings and or specified herein, are minimum pipe sizes. Pipe sizes shall be increased at no additional cost to the Contract if so required by applicable codes

and ordinances, or if sizes are not available in certain materials and equipment. Under no circumstances shall pipe sizes be decreased.

1.4 REGULATORY REQUIREMENTS

- A. Plumbing work to Conform to the most recent editions of the City of El Paso, Texas applicable codes and ordinances, International Plumbing Code-2015, International Energy Conservation Code-2015.
- B. Conform to the most recent editions of the Texas Accessibility Standards (TAS) Americans with Disabilities Act (ADA).
- C. Materials specified herein are acceptable products to these specifications, but are not necessarily acceptable to applicable local codes and ordinances. It is the responsibility of the Contractor to provide materials, from the options listed herein, that are acceptable to both these specifications and applicable local codes and ordinances.
- D. Under PART 2- PRODUCTS where acceptable products and models are called out by product “acceptable manufacturer and model or approved equal”, contractor may substitute an equal product and submit that product to the Owner’s Representative for approval prior to ordering product. Where it is called out “acceptable manufacturers and models” contractor shall select from one of those listed and submit it to the Owner’s Representative.

1.5 SUBMITTALS

- A. Submit product data on valves, fixtures and trim, plumbing specialties and equipment and other items specified herein and shown on the drawings to the Owner's Representative for review.
- B. Submit product data on pipe materials, fittings, valves and accessories specified within this Section in accordance with Section 013300 Submittal Procedures.
- C. Submit certificates required within this specification section in accordance with Section 013300 Submittal Procedures

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

- A. Domestic Water Piping (Within 5 feet of the building).

1. Interior aboveground – 2-1/2"-inch diameter and less. Pipe. copper tubing, ASTM B88, Type "L" hard drawn. Fittings. ANSI B16.22 wrought copper, ANSI B16.18 cast copper or copper press fittings with EPDM O-rings as manufactured by Pro-Press or approved equal. Joints: ANSI/ASTM B32, solder, Grade 95TA or press type.
 2. Interior and exterior, below ground, 2-1/2-inch and less. Pipe: copper tubing, ASTM B88, Type "K" hard drawn or annealed. Fittings: ANSI/ASME B16.18, cast copper or ANSI/ASME B16.22, wrought copper. Joints: AWS A5.8, BCuP silver braze.
- B. Sanitary Sewer Waste and Vent (Within 5 feet of the building).
1. Interior (non-plenum areas) and exterior above and below ground. Pipe. PVC, ASTM D2665, Schedule 40. Fittings. PVC, DWV type, Schedule 40. Joints: ASTM D2855 and D2564, solvent weld.

2.2 VALVES

- A. Ball Valves. For Water Shut-Off and Throttling.
1. 2" and less. MSS-SP-110 and NSF 61, lead free, 400 PSI working pressure, brass or bronze construction, reinforced TFE seat and Viton seal materials, lever handle, threaded or soldered connections. Throttling valves shall be provided with memory stops.
- B. Check Valves. For Water.
1. Conforms to MSS-SP-80, swing type, 200 PSI minimum working pressure, NFS 61, lead free, brass or bronze construction, bronze disc, PTFE seat, threaded or soldered connections.
- C. Vacuum Relief Valves. For Water Heater Tank.
1. Conform to ANSI Z21.22, lead free, swing type, 200 PSI minimum working pressure, brass or bronze construction, silicone disc, Buna-N o-ring, glass filled polysulfone float stainless steel spring and threaded connections.

2.3 PIPELINE STRAINERS

- A. Strainers shall be full line size of connecting piping, with ends matching piping system materials. Select strainers for 125 psi working pressure, with Type 304 stainless steel screens, with 3/64" perforations @ 233 per sq. in. Strainers shall be threaded ends, cast-iron body, screwed screen retainer with centered blowdown fitted with pipe plug.

2.4 INSULATION

- A. Foamed plastic flexible pipe covering - ASTM C534, .27 at 75°F thermal conductivity, maximum flame spread of 25 and smoke density of 50.

Acceptable manufacturers and models or approved equal:

Armstrong-Cork	Armaflex
Rubatex	INSUL-TUBE 180
IMCOA	Imcolock

- B. Fiberglass pipe insulation - ASTM C547, Class 1. Jackets for piping shall be ASTM C921, Type I for piping with temperatures below ambient and Type II for piping with temperatures above ambient. Encase pipe fittings insulation with one piece premolded PVC fitting covers.

Acceptable manufacturers or approved equal:

Owens-Corning Fiberglass
Certainteed Corp.
Knauf Fiberglass
Manville Products Corp.

- C. Staples, bands, wire, cements, adhesives, sealers and protective finishes as recommended by insulation manufacturer for applications indicated.

2.5 HANGERS AND SUPPORTS

- A. Provide hangers and supports in accordance with Manufacturer Standardization Society (MSS) SP-58, SP-69 and SP-89.

2.6 PLUMBING SPECIALTIES

- A. Floor Drains.

1. FD-1. Cast iron body, double drainage flange, weepholes, bottom outlet, 6" diameter nickel bronze adjustable flat strainer, and non-puncturing flashing collar.

Acceptable manufacturers and models or approved equal:

Josam	30,000-A
Smith	2010-A

Wade	W-1100
Zurn	Z-415

B. Trench drains (TD-1).

1. General. Provide modular trench drain system of fiberglass channels, coated steel frames of welded construction, ductile iron grates.
2. Channels. Interlocking presloped fiberglass modular units with 12" minimum inside width, 1% continuous slope (no neutral channels), and shall have a radiuses bottom of not less than 2 inches.
3. Strainer. Wire strainer to fit outlet diameter.
4. Frames. Coated steel frame shall be of all welded construction. Concrete anchors shall be welded to frame not less than 20 inches on center, both sides. Frame crossbars used to hold grating in place shall be welded to trench frame not less than 20 inches on center. Each crossbar shall have a threaded hole to accept locking bolt and washer from grate. [1/4" thick Z-type angle frame shall be provided to protect chipping of floor.]
5. Grating. Grating shall be ductile iron capable of withstanding Class E loading. Each grate to lock down to trench frame.
6. Installation. Trench drain system shall be installed in strict accordance with manufacturer's recommendations.

Acceptable Manufacturers and Models:

Aquaduct	[400] [800] Series
Zurn	Flo-Thru Series
Mea-Josam	[100] [200] [300] Series

C. Cleanout.

1. YCO-1. Yard cleanout, cast iron body, with straight body for caulking into soil pipe hub with countersunk tapered threaded bronze plug. Provide "T" handle wrench.

Acceptable manufacturers and models or approved equal:

Josam	58190-22
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Smith	4283
Wade	W-8530
Zurn	Z-1449-BP

2. DYCO. Double yard cleanout, cast iron body, with straight body for caulking into soil pipe hub with countersunk tapered threaded bronze plug and double cleanout T. Provide "T" handle wrench.

Acceptable manufacturers and models or approved equal:

Josam	58710
Smith	4402
Wade	W-8450R
Zurn	Z-1450-RD

3. WCO. Wall cleanout, Recessed type, cast iron body with threaded brass plug, flush mounted stainless steel access cover with countersunk center screw [and vandal resistant].

Acceptable manufacturers and models or approved equal:

Josam	58710
Smith	4402
Wade	W-8450-R
Zurn	Z-1441-Z

D. Hydrants and Hose Bibbs.

1. NWH-1. Non-freeze wall hydrant, exposed type, chrome plated brass or nickel bronze finish on brass casting body, 3/4" hose thread nozzle, integral vacuum breaker, loose key handle. Vacuum breaker to be in conformance with ANSI/ASSE 1011.

Acceptable manufacturers and models or approved equal:

Woodford	65
Josam	71050
Smith	5609
Wade	W-8620
Zurn	Z-1310

E. Water Hammer Arresters.

1. WHA. ASSE 1010 and PD1 WH-201, permanently sealed bellows or expanding chamber. Sizing symbols indicated on drawings are standard classification established by PD1-WH201.

F. Floor Drain Trap Protection Devices.

1. Trap Protection Device. ASSE 1072 Certified, designed to allow wastewater to open and adequately discharge floor drain through its interior and closes and returns to original position after wastewater discharge is complete.

Acceptable manufacturers and models or approved equal:

Proset Systems	Trap Guard
SureSeal	Inline Trap Seal
Smith	2692

G. Interceptors

1. Sand/Oil Separator SOS-1 shall be an epoxy lined precast concrete unit with 24" diameter heavy duty cast iron frame and cover with concrete extension rings to position cover flush with grade with separation chamber, and coalescer. See Schedule on Drawing for capacity.

Acceptable manufacturer and model or approved equal:

PARK	CMP-1
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2. Sample Well shall be a 15" diameter epoxy lined precast concrete unit with cast iron frame and cover set flush with concrete or 4 inches above turf grade.

Acceptable manufacturer and model or approved equal:

PARK	SWB-154
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H. Backflow Preventers.

1. RPB. Reduced pressure backflow preventer 2" and smaller; ANSI/ASSE 1013; complete unit of two independently acting check valves together with an automatically operating pressure relief valve, two ball valves, strainer, and four test cocks, bronze or stainless steel body and internal parts, 150 psi working pressure, and shall comply with AWWA Standard C506.

I. Flashings

1. Sheet lead shall be 4 pound weight.
2. Sheet copper shall be 16 ounce weight.

2.7 PLUMBING FIXTURES

A. Combination Water Closets/Flush Valves.

1. WC-1. TAS / ADA handicapped 16-1/2" to 17-1/2" high, floor mounted, HET flush valve type, with a MaP performance rating of 1000 as tested by Veritec Consulting, Inc, bottom outlet, white vitreous china, siphon jet action, elongated bowl, 2-1/8" diameter fully glazed trapway, 1-1/2" top inlet spud, designed to operate on 1.28 gallons per flush maximum. Flush-valve shall be exposed type, chrome-plated, non-hold open, piston or diaphragm type, 4 year life battery powered sensor operated with manual override button, 1" supply inlet, screw driver back-check angle stop, vacuum breaker, 1-1/2" top outlet spud with wall and spud flanges and 1.28 gallons per flush maximum. Inlet of flush-valve shall be 11-1/2" above rim of water closet.

Acceptable manufacturers and models or approved equal:

American Standard	Fixture: 3043.001.020
	Flush Valve: 6065.121.002

B. Water Closet Trim

1. Seat for water closets. White polypropylene, posture molded, elongated, open front, concealed one piece stainless steel self-sustaining check hinges and integral molded bumpers.

Acceptable manufacturers and models or approved equal:

American Standard	5901.100.020
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2. Supply and stop for WC-1. Through to wall angle type, chrome plated brass, 1/2" threaded or soldered inlet, by 3/8" O.D. compression type outlet. 3/8" O.D. chrome plated flexible copper riser and wall escutcheon.

C. Lavatory and Trim.

- ### Acceptable Manufacturers and Models:

2. Point of use thermostatic mixing valve for lavatories L-1. Chrome plated, thermostatic mixing valve for installation into hot water supply to lavatory faucet, ASSE 1070 listed for control of temperature of hot water, NFS 61 lead free bronze body, stainless steel disc and springs, Buna-N o-rings, integral check valves feature. Adjustable from 100 to 120 degrees F and factory set at 105 degrees F. 3/8" compression connections and tee.

Watts Series LFUSG-B

- Acceptable Manufacturer:

220000 - 9

7. Carrier for wall mounted lavatories shall be floor supported, compatible with lavatory, adjustable through wall frame, steel uprights, block foot supports, concealed arms and accessories.

Acceptable Manufacturers:

Josam
Smith
Wade
Zurn

D. Sink and Trim.

1. S-1. Countertop mounted, handicapped, single compartment, 18 gauge stainless steel, faucet deck, self-rim, with undercoated underside, off-center drain, three (3) 1-1/2" diameter faucet holes, 4" on center, size. 25 x 21" x 6" deep.

Acceptable Manufacturers and Models:

Elkay	LRAD-2512
Just	SL-ADA-2125-A-GR

2. Faucet for S-1. Chrome plated brass, deck mount, 8" centers swing gooseneck laminar flow spout with 8" reach (centerline of spout inlet to centerline of spout outlet) and 4" wrist blade handles. Maximum flow is 2.2 gpm.

Acceptable Manufacturers and Models:

Chicago Faucet	201A-GN8A
T&S Brass	B-0866-04-135X
Speakman	SC-3004-8
Zurn	Z-831C4
Moen	8133-S007
American Standard	7230.372H

3. Supplies and Stops for sinks. Through the wall angle type, chrome plated lead free brass, 1/4 turn, 1/2" threaded or soldered inlet by 3/8" O.D. compression type outlet, 3/8" O.D. chrome-plated flexible copper riser and wall escutcheon.
4. Strainer and Tailpiece for sinks. Stainless steel body, conical strainer, and tailpiece, with neoprene stopper. Size: 1-1/2" diameter.

5. P-Trap for sinks. 17 gauge, chrome plated brass and wall escutcheon. Size 1-1/2" diameter.

E. Janitor Sink and Trim.

1. JS-1. Floor mounted, molded polyester or fiberglass material, size. 24" x 24" x 10", 3" drain, mop hanger, hose and hose bracket, vinyl bumper-guard, removable combination dome strainer and stainless steel lint basket, white color.

Acceptable Manufacturers and Models:

Fiat	MSB 2424
Mustee	63
Swan	MS-2424

2. Faucet for JS-1. Chrome plated brass, 3/4" hose thread outlet, wall mounted for concealed supply pipe, wall brace, integral stops, pail hook, and vacuum breaker.

Acceptable Manufacturers:

Chicago Faucet	897
T&S Brass	B-665
Zurn	Z-841M1
Delta	28C2383

3. Trap for JS-1. 3" under floor.

F. Electric Water Coolers and Trim

1. EWC-1. Combination electric water cooler/bottle filler station, twin unit bi-level TAS handicapped for front wheelchair access, wall-mounted, front and side push bars, stainless steel top and backsplash, stainless steel cabinet. Low unit shall be mounted from finished floor up 36" to top of bubbler for handicapped. Unit shall have 3000 gallon capacity filtration system certified to NSF/ANSI 42 and 53. Electric water cooler shall be provided with flexible bubbler guard. Water cooler shall deliver 8.0 GPH of 50°F water, based upon 80°F inlet water temperatures, and 90°F ambient air temperature. Bottle filler shall deliver 1.1 GPM flow rate of water. Unit shall be lead free design and certified to NSF/ANSI 61 and 372.

Acceptable Manufacturer and Model or Approved Equal:

Elkay	LZSTL8WSSK
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Acceptable Manufacturers (same appearance, features and design as model specified above):

Haws
Oasis
Halsey Taylor
Sunroc

2. Supply and stop for electric water coolers: Supplied through the wall, chrome-plated lead free brass, 1/4 turn, 1/2" female standard pipe thread inlet by 3/8" O.D. compression type outlet angle stop, wheel or four-armed handle, with flexible riser and wall escutcheon.
3. P-trap for electric water coolers: 17-gauge chrome-plated brass, size 1- 1/4", integral cleanout, and wall escutcheons.
4. Carriers for electric water coolers: Mounted on concrete block walls only shall be wall-mounted type, compatible with specified electric water cooler, complete with hanger wall plate, adjustable through the wall supporting rods and accessories.

Acceptable Manufacturers:

Josam
Smith
Wade
Zurn

G. Refrigerator Ice Maker Box

1. RMB-1. Recessed PVC box with 1/2" chrome plated 1/4 turn ball valve with CPVC or NPT connection.

Acceptable Manufacturer and Model:

IPS 9701

H. Emergency Shower/Eyewash Station

1. ESE-1. Exposed type with floor flange, galvanized steel, piping plastic shower head actuated by a stay open ball valve with rigid pull rod and handle, eyewash with large stainless steel bowl and two soft stream heads actuated by stay open ball valve with push-flag. Pipe sizes shall be 1-1/4" water inlet and 1-1/4" drain.

Acceptable Manufacturer and Model:

Speakman	SE-603
Haws	8200
Guardian	G1902
Bradley	S19-310

2.8 PLUMBING EQUIPMENT

A. Domestic Water Heater

1. DWH-1. Energy efficient, insulated tank with minimum "R" value of 16, residential electric vertical type, porcelain lined tank, anode protection, drain valve, safety relief valve, high-temperature cut-off, individual operating thermostats, insulated tank, baked enamel exterior steel jacket, and UL listed.

Acceptable Manufacturer and Model:

A. O. Smith EJCT Series

2. Circulation pump HWCP-1. Inline type, flanged connections, rated for 125 psi at 220°F, single stage, vertical split case, all bronze or stainless steel and provided with oil cups. See Schedule for capacity.

Acceptable Manufacturers or approved equal:

Bell & Gossett
Armstrong
Taco
Grundfos

3. Time clock for circulation pump. On-off control, 24 hour 7 days a week SPST mechanical time switch, NEMA 1 enclosure, 40 amp rated at 120 VAC, UL listed.

Acceptable manufacturer and model or approved equal:

Tork 1101

4. Expansion Tank for ASME Water Heater. ASME coded bladder type tank, factory pre-charged, fabricated steel shell, heavy duty butyl FDA approved bladder, 125 PSIG working pressure, 240°F operating temperature. Tank head shall be galvanized or polypropylene lined. Pre-charge tank to static pressure of system.

Acceptable manufacturers and models or approved equal:

ELBI
Watts

DTS Series
DETA Series

5. Dielectric Waterway Fittings for Water Heater. ASTM F492, constructed of zinc electroplated steel casing, NSF/FDA listed lining, 225 degree F temperature rated, 300 psi pressure rated, threaded connections.

Acceptable manufacturer and model or approved equal:

Precision Plumbing Products Clearflo Series

2.9 PIPING PENETRATIONS

A. Provide pipe sleeves of one of the following:

1. Sheet-Metal. Fabricate from galvanized sheet metal; round tube closed with snap-lock joint, welded spiral seams, or welded longitudinal joint. Fabricate from the following gauges. 3" and smaller, 20 gauge; 4" to 6" 16 gauge; over 6", 14 gauge.
2. Steel-Pipe. Fabricate from Schedule 10 (minimum) steel pipe; remove burrs.
3. Floor sleeves shall be provided with water stop around perimeter of sleeve.

B. Caulked Seals. Provide seals for penetrations through interior walls of one of the following:

1. Mineral Wool. Packed tightly between sleeve and pipe.

C. Mechanical Seals.

1. General. Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with bolts and pressure plates which cause rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation.
2. Manufacturer. Subject to compliance with requirements, provide mechanical sleeve seals of one of the following or approved equal.

Thunderline Corp.

D. Fire/Smoke Barrier Seals.

1. Provide UL Listed fire/smoke seal systems conforming to both Flame "F" and Temperature "T" ratings required by local building code for openings through smoke or fire-rated walls, and above grade floors, used as passage for mechanical components such as electrical conduit, piping or ductwork. The "F" rating must be a minimum of 1 hour but not less than the fire resistance rating of the assembly being penetrated. The "T" rating must be in accordance with the code authority.
2. Acceptable Manufacturer. Subject to compliance with requirements, provide fire/smoke barrier penetration seals of one of the following or approved equal.

3M Fire Protection Products.
Nelson; Unit of General Signal.
Specified Technologies, Inc.
Firestop Systems, Inc.
Hilti, Inc.
Metacaulk

2.10 IDENTIFICATION

- A. Provide 1-1/2" piping labels at 25' intervals and 1-1/2" valve tags numbered and scheduled. Place schedule in Mechanical Room under glass and mounted to wall. In addition, provide labels for all equipment.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

- A. Installation to be in accordance with the most recent edition of the City of El Paso, Texas applicable codes and ordinances and the International Plumbing Code-1997.
- B. Provide chrome plated brass stops on fixtures.
- C. Provide non-conducting dielectric connections whenever joining dissimilar metals.
- D. Fixtures and trim to be installed in accordance with manufacturer's recommendations.
- E. Install fixtures and equipment level, plumb, and at right angles to walls.
- F. Provide carriers on wall mounted fixtures.
- G. Seal fixtures to wall and floor surfaces with white silicone sealant.

- H. Provide manufactured removable insulation covering kit on stops and supplies, tailpieces and P-traps of handicapped lavatories.
- I. Provide water hammer arresters on hot and cold water supplies to plumbing fixtures. Water hammer arresters to be as shown on diagrams and, if not shown, provide for each fixture in accordance with Standard PDI-WH-201. Sizing shown on the drawings to be in accordance with PD1-WH-201.
- J. Provide excavation, bedding, backfilling and compaction for underfloor plumbing piping. Excavation shall be down to 6" below pipe. Bedding material shall be clean sand from 6" below pipe to 6" above pipe. Backfill shall be excavated material free from any debris. Compact 6" increments to 95% proctor per ASTM D1557.
- K. Vent through roof to be made watertight by the use of 4 pound lead flashing made into an integral skirt or flange. Flashing shall be suitably formed and the skirt or flange shall extend not less than 8" from the pipe and shall be set over the roof membrane in a solid coating of bituminous cement. Extend flashing up the pipe and turn down into the pipe to form a waterproof joint. The annular space between the flashing and the bare pipe shall be sealed with tightly packed fiberglass wool insulation.
- L. Extend floor cleanouts to flush with finished floor. Lubricate threaded cleanout plugs with non-hardening teflon pipe dope.
- M. Trap drains connected to sanitary sewer.
- N. Install floor and area drains with top depressed 1/2" below finished floor.
- O. Inlet of overflow drain to be 2" above inlet of adjacent roof drain.
- P. Outlet of plumbing vents and flues to be located a minimum of 25'-0" from fresh air intakes. Provide offset as required.
- Q. Piping hangers shall be sized large enough to allow insulation to pass through. Hangers for piping 2-1/2" and greater shall be provided with pipe covering protection saddle, or high compressive strength insulation saddle. Hangers for piping 2" and less shall be provided with pipe covering shields. On cold or chilled water piping provide vapor barrier through hanger.
- R. Materials within ducts or plenums (ceiling spaces used as supply or return air plenums) shall have a flame-spread index of not more than 25 and a smoke developed rating of not more than 50 when tested in accordance with the Test for Surface Burning Characteristics of Materials, U.B.C. Standard No. 42-1.

- S. Installation of equipment shall be in accordance with the manufacturer's recommendations.
- T. Seal piping penetrations to achieve fire and smoke resistance equivalent to fire and smoke assembly rating.
- U. Handicapped fixtures shall be provided in accordance with ADA regulations.
- V. Provide identifying tags and markers on piping valves.
- W. Provide access for serving, maintenance, and general inspection. Coordinate the location of concealed equipment and devices requiring access with location of access panels and doors. Allow ample removal space and coordinate piping locations so not to block access. Provide access for the following equipment.

Valves

- X. Provide record drawings to indicate revisions to piping, size and location, both exterior and interior; including locations of equipment, inverts and locations of underground piping, mains and branches of piping systems with valves located and numbered, items requiring maintenance, etc.
- Y. Provide operation and maintenance manuals showing description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, complete nomenclature and commercial numbers of replacement parts, printed operating procedures, routine preventive maintenance, servicing instructions and lubrication charts.

3.2 INSULATION.

- A. Insulate domestic cold and hot water, non-potable and make-up water, and horizontal roof drain piping.
- B. Insulation thickness schedule.

Cold Water Piping

Fiberglass. 1" thick for all pipe sizes.

Foamed Plastic. 1/2" thick for all pipe sizes.

Hot Water Piping

Fiberglass and Foamed Plastic. 1" thick for pipe sizes up to 1", 1-1/2" thick for pipe sizes from 1-1/4" to 2", 2" thick for pipe sizes from 2-1/2" and larger.

3.3 PIPING CONNECTIONS.

A. Threaded Connections

1. Threaded joints shall be in accordance with ANSI B1.20.1. Threaded joints shall be made up teflon tape or lead free pipe joint compound applied to the male thread only. Should a joint be loosened after being made up, it shall not be made up a second time unless the threads are cleaned and new compound applied.
2. Steel piping which is assembled with screwed joints shall have exposed threads thoroughly primed with a coat of lead free rust resistant paint. Paint immediately after installation. This shall apply to both piping which is to be covered as well as uncovered.

B. Soldered Connections

1. Soldered joints shall be in accordance with ASTM B32. Flux shall be nonacid type. Remove composition discs from solder end valves during soldering. Pipe ends, fittings and valves shall be properly cleaned before soldering and wiped clean to remove flux and excess solder after soldering.

C. Copper Tubing Press Type. In lieu of providing soldered fittings in copper tubing, Installer may, as option, provide press connections, providing they are in accordance with following:

1. Press connections: Copper press fittings shall be made in accordance with the manufacturers installation instructions. The tubing shall be inserted into the fitting and the tubing marked at the shoulder of the fitting. The fitting alignment shall be checked against the mark on the tubing to assure the tubing is fully engaged (inserted) in the fitting. The joints shall be pressed using the tool approved by the manufacture.

D. Mechanically Formed Tee Connections for above ground use only. In lieu of providing tee fittings in copper tubing, Installer may, as option, provide mechanically formed tee connections, providing they are in accordance with following.

1. Size and wall thickness of both run tube and branch tube are listed by manufacturer of forming equipment as "Acceptable Application".
2. Height of drawn collar is not less than three times wall thickness of run tubing.
3. End of branch tube is notched to conform to inner curve of run tube, and dimpled to set exact penetration depth into collar.

4. Resulting joint is minimum of three times as long as thickness of thinner joint member, and brazed using B-CUP series filler metal.
- E. Welded joints shall be in accordance with AWS D10.12 and made by the oxyacetylene or electric process.
- F. Solvent cement connections.
 1. Solvent cement connections shall be joined with primer and PVC solvent cement complying to ASTM D2564. Solvent cement connections shall be in compliance with GSR Bulletin #SCJ-1 Solvent Cementing Procedure.

3.4 HANGER AND SUPPORT INSTALLATION

- A. Pipe hanger and support and equipment support materials and installation requirements are specified in Section 220529 Hangers and Supports for Plumbing Piping and Equipment.
- B. Piping hangers shall be sized large enough to allow insulation to pass through. Hangers for piping 2-1/2" and greater shall be provided with pipe covering protection saddle, or high compressive strength insulation saddle. Hangers for piping 2" and less shall be provided with pipe covering shields. On cold or chilled water piping provide vapor barrier through hanger.
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch.
- E. All sanitary waste stacks and storm drain downspouts 4" diameter and larger with vertical drops over 30'-0" shall be provided with joint restraint on the horizontal branch or offset below the vertical drop. Joint restraint shall be accomplished by threaded joints, grooved joints or a combination of pipe clamps and tie-rods as required in NFPA 24. Joint restraint below ground shall be accomplished by thrust blocks as required in NFPA 24. Vertical joint restraint shall be provided from the 90 degree ell at the bottom of the vertical drop through every joint up to the riser clamp at the floor penetration of the floor above. Horizontal joint restraint shall be provided from that same 90 degree ell through every joint on the horizontal branch.
- F. Install hangers for horizontal hard copper tubing with the following maximum spacing and the minimum rod sizes:
 1. 3/4 inch and smaller: Maximum span - 5 feet and minimum rod size - 3/8 inch.

2. 1 inch through 1-1/4 inch: Maximum span - 6 feet and minimum rod size - 3/8 inch.
 3. 1-1/2 inch through 2 inch: Maximum span - 8 feet and minimum rod size - 3/8 inch.
- G. Install hangers for horizontal PVC piping with the following maximum spacing and the minimum rod sizes:
1. 2 inch and smaller: Maximum span - 4 feet and minimum rod size - 3/8 inch.
 2. 2-1/2 inch and 3 inch: Maximum span - 4 feet and minimum rod size - 1/2 inch.
 3. Install supports for vertical PVC tubing every 4 feet.

3.5 PIPE PENETRATIONS.

- A. Sleeve or core drill new construction or core drill existing construction pipe penetrations as specified below where piping passes through walls, floors, and roofs. Do not penetrate structural members, or cut concrete reinforcement except as detailed on drawings, or as reviewed by Owner's Representative. Install penetrations accurately centered on pipe runs. Size penetrations so that piping and insulation (if any) will have free movement in sleeve, including allowance for thermal expansion; but not less than two pipe sizes larger than piping run. Where insulation includes vapor-barrier jacket, provide penetration with sufficient clearance for installation. When sleeves are required, install length of sleeve equal to thickness of construction penetrated, and finish flush to surface; except floor sleeves. Extend floor sleeves two inches above finished floor. Provide temporary support of sleeves during placement of concrete and other work around sleeves, and provide temporary closure to prevent concrete and other materials from entering sleeve. Pipe penetrations shall be as follows.
1. New floors on grade. Provide sleeved penetrations for piping except piping two inches and less and waste, drain, and vent piping. Piping not requiring sleeves shall be provided with 30 lb. asphalt saturated roofing felt wrapped around pipe through the thickness of the floor with concrete floor placed up to roofing felt.
 2. New floors above grade. Provide sleeved or core drilled penetrations for piping.
 3. Existing Floors Above Grade. Provide core drilled penetrations for piping.
 4. New and Existing Walls. Provide sleeved or core drilled penetrations for piping.
 5. Floor type drains, cleanouts, and water closet waste connections do not require sleeved or core drilled penetrations. Concrete shall be placed tight to connection.

B. Pipe Sleeves. Install in accordance with the following:

1. Install sheet metal on steel pipe sleeves in interior walls.
2. Install steel pipe sleeves in interior floors above grade.
3. Install galvanized steel pipe sleeves in floors on grade and in exterior walls above grade and below grade.

C. Penetration Seals.

1. Install caulked seals as follows.
 - a. In interior walls where piping passes from one space to another, where any one of the spaces the piping penetration is not concealed by a ceiling.
 2. Install mechanical seals in accordance with manufacturer's recommendations as follows.
 - a. In interior floors on grade.
 - b. In exterior walls above grade and below grade.
 - c. In roof penetrations except vent piping, flue piping, roof or overflow drain piping or any other piping as otherwise detailed on drawing.
 3. Install fire barrier seals in accordance with manufacturer's recommendations.
 4. Piping penetrations through conventional built-up roof shall be made water tight by flashing and counter flashing in roof system and sealed with bituminous sealant. Piping penetrations through non-conventional roof such as membrane, standing seam, etc. shall be in accordance with the roofing manufacturer's requirements and meet the roofing manufacturer's warranty.

3.6 TESTING

- A. Testing piping systems in accordance with the most recent editions of the City of El Paso, Texas applicable codes and ordinances and the International Plumbing - 2009.
- B. Test water heater to ensure proper operation.

3.7 FLUSHING AND DISINFECTION

- A. Flush and disinfect domestic water piping system in accordance with the most recent editions of the City of El Paso, Texas applicable codes and ordinances and the International Plumbing Code - 2009.

3.8 ADJUSTING AND CLEANING

- A. Adjust and balance stops for intended water flow to fixtures without splashing, noise or overflow.
- B. At completion, clean plumbing fixtures.

END OF SECTION

Special Specification RMA11

**Section 260519; 260526; 260529; 260533; 260536; 260543; 260553;
260573.13; 260573.16; 260573.19; 260923; 262213; 262416; 262726;
262816; 262913.03; 262923; 264113; 265119; 265619**

**LED Interior Lightning; 265619FL-LED Exterior Lightning/Wiring
Devices/Panelboards/262816FL-Enclosed Switches and Circuit
Breakers/Hangers and Supports for Electrical Systems/Grounding
and Bonding for Electrical Systems/Raceway and Boxes for
Electrical System/Lighting Control Devices/Low-Voltage Electrical
Power Conductors and Cables/Underground Ducts and Raceways
for Electrical Systems/Telecommunication and Fire Alarm
Allowance/Taxiway LED Exterior Lighting (Pole Mounted Solar
Fixtures)/Taxiway LED Exterior Lighting (Solar Powered Taxiway
Lighting)**

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Copper building wire rated 600 V or less.
2. Metal-clad cable, Type MC, rated 600 V or less.
3. Connectors, splices, and terminations rated 600 V and less.

1.2 DEFINITIONS

A. RoHS: Restriction of Hazardous Substances.

B. VFC: Variable-frequency controller.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 COPPER BUILDING WIRE

- A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Alpha Wire Company.
 - 2. American Bare Conductor.
 - 3. Belden Inc.
 - 4. Cerro Wire LLC.
 - 5. Encore Wire Corporation.
 - 6. General Cable Technologies Corporation.
 - 7. Okonite Company (The).
 - 8. Service Wire Co.
 - 9. Southwire Company.
 - 10. WESCO.
- C. Standards:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
 - 2. RoHS compliant.
 - 3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."
- D. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.
- E. Conductor Insulation:
 - 1. Type THHN and Type THWN-2: Comply with UL 83.

2.2 METAL-CLAD CABLE, TYPE MC

- A. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AFC Cable Systems; a part of Atkore International.

2. Alpha Wire Company.
3. American Bare Conductor.
4. Belden Inc.
5. Encore Wire Corporation.
6. General Cable Technologies Corporation.
7. Okonite Company (The).
8. Service Wire Co.
9. Southwire Company.
10. WESCO.

C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. Comply with UL 1569.
3. RoHS compliant.
4. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Circuits:

1. Single circuit.
2. Power-Limited Fire-Alarm Circuits: Comply with UL 1424.

E. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.

F. Ground Conductor: Insulated.

G. Conductor Insulation:

1. Type THHN/THWN-2: Comply with UL 83.

H. Armor: Steel, interlocked.

I. Jacket: PVC applied over armor.

2.3 CONNECTORS AND SPLICES

- A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. 3M Electrical Products.
 - 2. AFC Cable Systems; a part of Atkore International.
 - 3. Gardner Bender.
 - 4. Hubbell Power Systems, Inc.
 - 5. Ideal Industries, Inc.
 - 6. ILSCO.
 - 7. NSi Industries LLC.
 - 8. O-Z/Gedney; a brand of Emerson Industrial Automation.
 - 9. Service Wire Co.
 - 10. TE Connectivity Ltd.
 - 11. Thomas & Betts Corporation; A Member of the ABB Group.
- C. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.
- D. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.
 - 1. Material: Copper.
 - 2. Type: One hole with standard barrels.
 - 3. Termination: Compression.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders: Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- B. Feeders: Copper for feeders smaller than No. 4 AWG; copper or aluminum for feeders No. 4 AWG and larger. Conductors shall be solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- C. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- D. VFC Output Circuits Cable: Extra-flexible stranded for all sizes.
- E. Power-Limited Fire Alarm and Control: Solid for No. 12 AWG and smaller.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Service Entrance: Type THHN/THWN-2, single conductors in raceway.
- B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway.
- C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN/THWN-2, single conductors in raceway.
- D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.
- E. Exposed Branch Circuits, Including in Crawlspace: Type THHN/THWN-2, single conductors in raceway.
- F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway or Metal-clad cable, Type MC.
- G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.
- H. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
- B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.
- C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.

- E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."
- G. Complete cable tray systems installation according to Section 260536 "Cable Trays for Electrical Systems" prior to installing conductors and cables.

3.4 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- B. Make splices, terminations, and taps that are compatible with conductor material.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

3.5 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."
- B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.6 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
 2. Perform each of the following visual and electrical tests:
 - a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
 - b. Test bolted connections for high resistance using one of the following:
 - 1) A low-resistance ohmmeter.
 - 2) Calibrated torque wrench.
 - 3) Thermographic survey.
 - c. Inspect compression-applied connectors for correct cable match and indentation.
 - d. Inspect for correct identification.
 - e. Inspect cable jacket and condition.
 - f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable for a one-minute duration.
 - g. Continuity test on each conductor and cable.
 - h. Uniform resistance of parallel conductors.
 3. Initial Infrared Scanning: After Substantial Completion, but before Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.
 - a. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - b. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
 4. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.
- C. Cables will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports to record the following:
1. Procedures used.
 2. Results that comply with requirements.
 3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION

SECTION 260526 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes grounding and bonding systems and equipment.
- B. Section includes grounding and bonding systems and equipment, plus the following special applications:
 - 1. Underground distribution grounding.
 - 2. Ground bonding common with lightning protection system.
 - 3. Foundation steel electrodes.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans showing dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:
 - 1. Test wells.
 - 2. Ground rods.
 - 3. Ground rings.
 - 4. Grounding arrangements and connections for separately derived systems.
- B. Qualification Data: For testing agency and testing agency's field supervisor.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Plans showing as-built, dimensioned locations of system described in "Field Quality Control" Article, including the following:
 - 1) Test wells.
 - 2) Ground rods.

- 3) Grounding arrangements and connections for separately derived systems.
- b. Instructions for periodic testing and inspection of grounding features at test wells grounding connections for separately derived systems Insert locations based on NFPA 70B.
 - 1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
 - 2) Include recommended testing intervals.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Certified by NETA.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

2.2 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Advanced Lightning Technology, Ltd.
 2. Burndy; Part of Hubbell Electrical Systems.
 3. Dossert; AFL Telecommunications LLC.
 4. ERICO; a brand of nVent.
 5. Fushi Copperweld Inc.
 6. Galvan Industries, Inc.; Electrical Products Division, LLC.
 7. Harger Lightning & Grounding.
 8. ILSCO.
 9. O-Z/Gedney; a brand of Emerson Industrial Automation.
 10. Robbins Lightning, Inc.
 11. Siemens Industry, Inc., Energy Management Division.
 12. Thomas & Betts Corporation; A Member of the ABB Group.

2.3 CONDUCTORS

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B3.
 - 2. Stranded Conductors: ASTM B8.
 - 3. Tinned Conductors: ASTM B33.
 - 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
 - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - 6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
 - 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
- C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.4 CONNECTORS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- C. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
- D. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.
- E. Cable-to-Cable Connectors: Compression type, copper or copper alloy.
- F. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.

- G. Conduit Hubs: Mechanical type, terminal with threaded hub.
- H. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.
- I. Lay-in Lug Connector: Mechanical type, copper rated for direct burial terminal with set screw.
- J. Service Post Connectors: Mechanical type, bronze alloy terminal, in short- and long-stud lengths, capable of single and double conductor connections.
- K. Signal Reference Grid Clamp: Mechanical type, stamped-steel terminal with hex head screw.
- L. Straps: Solid copper. Rated for 600 A.
- M. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.
- N. Water Pipe Clamps:
 - 1. Mechanical type, two pieces with stainless-steel bolts.
 - a. Material: Die-cast zinc alloy.
 - b. Listed for direct burial.
 - 2. U-bolt type with malleable-iron clamp and copper ground connector rated for direct burial.

2.5 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet.
- B. Chemical-Enhanced Grounding Electrodes: Copper tube, straight or L-shaped, charged with nonhazardous electrolytic chemical salts.
 - 1. Termination: Factory-attached No. 4/0 AWG bare conductor at least 48 inches long.
 - 2. Backfill Material: Electrode manufacturer's recommended material.
- C. Ground Plates: 1/4 inch thick, hot-dip galvanized.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2/0 AWG minimum.
 - 1. Bury at least 30 inches below grade.
 - 2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.
- C. Grounding Conductors: Green-colored insulation.
- D. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - 1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
 - 2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.
- E. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
 - 3. Connections to Ground Rods at Test Wells: Bolted connectors.
 - 4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING AT THE SERVICE

- A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 GROUNDING SEPARATELY DERIVED SYSTEMS

- A. Generator: Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator.

3.4 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements.
- B. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

3.5 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 - 1. Feeders and branch circuits.
 - 2. Lighting circuits.
 - 3. Receptacle circuits.
 - 4. Single-phase motor and appliance branch circuits.
 - 5. Three-phase motor and appliance branch circuits.
 - 6. Flexible raceway runs.
 - 7. Armored and metal-clad cable runs.
- C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
- E. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

- F. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.6 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.
- C. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.
 - 1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
 - 2. Use exothermic welds for all below-grade connections.
 - 3. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches deep, with cover.
 - 1. Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
- E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
 - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
 - 3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.
- F. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.
- H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.
- I. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; using electrically conductive coated steel reinforcing bars or rods, at least 20 feet long. If reinforcing is in multiple pieces, connect together by the usual steel tie wires or exothermic welding to create the required length.
- J. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.
1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
 2. Make connections with clean, bare metal at points of contact.
 3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
 4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
 5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform tests and inspections.
- E. Tests and Inspections:
 - 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 - 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 - 3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells and at individual ground rods. Make tests at ground rods before any conductors are connected.
 - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method according to IEEE 81.
 - 4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- F. Grounding system will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports.
- H. Report measured ground resistances that exceed the following values:
 - 1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
 - 2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
 - 3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
 - 4. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).
 - 5. Substations and Pad-Mounted Equipment: 5 ohms.

- I. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel slotted support systems.
2. Conduit and cable support devices.
3. Support for conductors in vertical conduit.
4. Structural steel for fabricated supports and restraints.
5. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
6. Fabricated metal equipment support assemblies.

1.2 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.
- B. Welding Qualifications: Qualify procedures and personnel according to the following:
1. AWS D1.1/D1.1M.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design hanger and support system.
- B. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
1. Flame Rating: Class 1.
 2. Self-extinguishing according to ASTM D 635.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch- diameter holes at a maximum of 8 inches o.c. in at least one surface.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit; a part of Atkore International.
 - b. B-line, an Eaton business.
 - c. CADDY; a brand of nVent.
 - d. Flex-Strut Inc.
 - e. Gripple Inc.
 - f. GS Metals Corp.
 - g. G-Strut.
 - h. Haydon Corporation.
 - i. Metal Ties Innovation.
 - j. MIRO Industries.
 - k. Thomas & Betts Corporation; A Member of the ABB Group.
 - l. Unistrut; Part of Atkore International.
 - m. Wesanco, Inc.
 2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
 3. Material for Channel, Fittings, and Accessories: Galvanized steel.
 4. Channel Width: 1-5/8 inches.
 5. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 6. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 7. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 8. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- B. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.
- D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.

- E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Hilti, Inc.
 - 2) ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - 3) MKT Fastening, LLC.
 - 4) Simpson Strong-Tie Co., Inc.
 2. Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) B-line, an Eaton business.
 - 2) Empire Tool and Manufacturing Co., Inc.
 - 3) Hilti, Inc.
 - 4) ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - 5) MKT Fastening, LLC.
 3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
 4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
 5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM F 3125/F 3125M, Grade A325.
 6. Toggle Bolts: All Stainless-steel springhead type.
 7. Hanger Rods: Threaded steel.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:
 - 1. NECA 1.
 - 2. NECA 101
 - 3. NECA 102.
 - 4. NECA 105.
 - 5. NECA 111.
- B. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- C. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
- D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.
- E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 - 1. Secure raceways and cables to these supports with two-bolt conduit clamps.
- F. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings, and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT IMC and RMC may be supported by openings through structure members, according to NFPA 70.

- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - 1. To Wood: Fasten with lag screws or through bolts.
 - 2. To New Concrete: Bolt to concrete inserts.
 - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - 4. To Existing Concrete: Expansion anchor fasteners.
 - 5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
 - 6. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
 - 7. To Light Steel: Sheet metal screws.
 - 8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

- B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place Concrete."
- C. Anchor equipment to concrete base as follows:
 - 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Touchup: Comply with requirements in Section 099113 "Exterior Painting" Section 099123 "Interior Painting" and Section 099600 "High-Performance Coatings" for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 260533 – RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal conduits and fittings.
2. Nonmetallic conduits and fittings.
3. Metal wireways and auxiliary gutters.
4. Nonmetal wireways and auxiliary gutters.
5. Surface raceways.
6. Boxes, enclosures, and cabinets.
7. Handholes and boxes for exterior underground cabling.

1.2 DEFINITIONS

A. GRC: Galvanized rigid steel conduit.

B. IMC: Intermediate metal conduit.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. Metal Conduit:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AFC Cable Systems; a part of Atkore International.
 - b. Allied Tube & Conduit; a part of Atkore International.
 - c. Anamet Electrical, Inc.
 - d. Calconduit.
 - e. Electri-Flex Company.
 - f. FSR Inc.
 - g. Korkap.
 - h. Opti-Com Manufacturing Network, Inc (OMNI).
 - i. O-Z/Gedney; a brand of Emerson Industrial Automation.
 - j. Perma-Cote.
 - k. Picoma Industries, Inc.
 - l. Plasti-Bond.

- m. Republic Conduit.
 - n. Southwire Company.
 - o. Thomas & Betts Corporation; A Member of the ABB Group.
 - p. Topaz Electric; a division of Topaz Lighting Corp.
 - q. Western Tube and Conduit Corporation.
 - r. Wheatland Tube Company.
- 2. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 3. GRC: Comply with ANSI C80.1 and UL 6.
 - 4. IMC: Comply with ANSI C80.6 and UL 1242.
 - 5. PVC-Coated Steel Conduit: PVC-coated IMC.
 - a. Comply with NEMA RN 1.
 - b. Coating Thickness: 0.040 inch, minimum.
 - 6. EMT: Comply with ANSI C80.3 and UL 797.
 - 7. FMC: Comply with UL 1; zinc-coated steel.
 - 8. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

B. Metal Fittings:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AFC Cable Systems; a part of Atkore International.
 - b. Allied Tube & Conduit; a part of Atkore International.
 - c. Anamet Electrical, Inc.
 - d. Calconduit.
 - e. Electri-Flex Company.
 - f. FSR Inc.
 - g. Korkap.
 - h. Opti-Com Manufacturing Network, Inc (OMNI).
 - i. O-Z/Gedney; a brand of Emerson Industrial Automation.
 - j. Perma-Cote.
 - k. Picoma Industries, Inc.
 - l. Plasti-Bond.
 - m. Republic Conduit.
 - n. Southwire Company.
 - o. Thomas & Betts Corporation; A Member of the ABB Group.
 - p. Topaz Electric; a division of Topaz Lighting Corp.
 - q. Western Tube and Conduit Corporation.
 - r. Wheatland Tube Company.
- 2. Comply with NEMA FB 1 and UL 514B.
- 3. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- 4. Fittings, General: Listed and labeled for type of conduit, location, and use.
- 5. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
- 6. Fittings for EMT:
 - a. Material: Steel or die cast.
 - b. Type: compression.

7. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
 8. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.
- C. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS AND FITTINGS

A. Nonmetallic Conduit:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AFC Cable Systems; a part of Atkore International.
 - b. Anamet Electrical, Inc.
 - c. Arnco Corporation.
 - d. CANTEX INC.
 - e. CertainTeed Corporation.
 - f. Champion Fiberglass, Inc.
 - g. Condux International, Inc.
 - h. Electri-Flex Company.
 - i. FRE Composites.
 - j. Kraloy.
 - k. Lamson & Sessions.
 - l. Niedax Inc.
 - m. RACO; Hubbell.
 - n. Thomas & Betts Corporation; A Member of the ABB Group.
 - o. Topaz Electric; a division of Topaz Lighting Corp.
 - p. United Fiberglass.
2. Listing and Labeling: Nonmetallic conduit shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Fiberglass:
 - a. Comply with NEMA TC 14.
 - b. Comply with UL 2515 for aboveground raceways.
 - c. Comply with UL 2420 for belowground raceways.
4. ENT: Comply with NEMA TC 13 and UL 1653.
5. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
6. LFNC: Comply with UL 1660.
7. Rigid HDPE: Comply with UL 651A.
8. Continuous HDPE: Comply with UL 651A.
9. Coilable HDPE: Preassembled with conductors or cables, and complying with ASTM D 3485.

10. RTRC: Comply with UL 2515A and NEMA TC 14.

B. Nonmetallic Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AFC Cable Systems; a part of Atkore International.
 - b. Anamet Electrical, Inc.
 - c. Arnco Corporation.
 - d. CANTEX INC.
 - e. CertainTeed Corporation.
 - f. Champion Fiberglass, Inc.
 - g. Condux International, Inc.
 - h. Electri-Flex Company.
 - i. FRE Composites.
 - j. Kraloy.
 - k. Lamson & Sessions.
 - l. Niedax Inc.
 - m. RACO; Hubbell.
 - n. Thomas & Betts Corporation; A Member of the ABB Group.
 - o. Topaz Electric; a division of Topaz Lighting Corp.
 - p. United Fiberglass.
2. Fittings, General: Listed and labeled for type of conduit, location, and use.
3. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
 - a. Fittings for LFNC: Comply with UL 514B.
4. Solvents and Adhesives: As recommended by conduit manufacturer.

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line, an Eaton business.
 2. Hoffman; a brand of Pentair Equipment Protection.
 3. MonoSystems, Inc.
 4. Square D.
- B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 Type 3R unless otherwise indicated, and sized according to NFPA 70.
1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

- D. Wireway Covers: Screw-cover type unless otherwise indicated.
- E. Finish: Manufacturer's standard enamel finish.

2.4 SURFACE RACEWAYS

- A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hubbell Incorporated; Wiring Device-Kellems.
 - b. MonoSystems, Inc.
 - c. Panduit Corp.
 - d. Wiremold / Legrand.

2.5 BOXES, ENCLOSURES, AND CABINETS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Adalet.
 - 2. Crouse-Hinds, an Eaton business.
 - 3. EGS/Appleton Electric.
 - 4. Erickson Electrical Equipment Company.
 - 5. FSR Inc.
 - 6. Hoffman; a brand of Pentair Equipment Protection.
 - 7. Hubbell Incorporated.
 - 8. Hubbell Incorporated; Wiring Device-Kellems.
 - 9. Kraloy.
 - 10. Milbank Manufacturing Co.
 - 11. MonoSystems, Inc.
 - 12. Oldcastle Enclosure Solutions.
 - 13. O-Z/Gedney; a brand of Emerson Industrial Automation.
 - 14. Plasti-Bond.
 - 15. RACO; Hubbell.
 - 16. Spring City Electrical Manufacturing Company.
 - 17. Thomas & Betts Corporation; A Member of the ABB Group.
 - 18. Topaz Electric; a division of Topaz Lighting Corp.
 - 19. Wiremold / Legrand.

- B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.
- C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
- E. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.
- F. Metal Floor Boxes:
 - 1. Material: Cast metal or sheet metal.
 - 2. Type: Fully adjustable.
 - 3. Shape: Rectangular.
 - 4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- G. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.
- H. Paddle Fan Outlet Boxes: Nonadjustable, designed for attachment of paddle fan weighing 70 lb.
 - 1. Listing and Labeling: Paddle fan outlet boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- I. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- J. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, with gasketed cover.
- K. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- L. Device Box Dimensions: 4 inches square by 2-1/8 inches deep 4 inches by 2-1/8 inches by 2-1/8 inches deep.
- M. Gangable boxes are prohibited.

- N. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 Type 3R with continuous-hinge cover with flush latch unless otherwise indicated.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2. Nonmetallic Enclosures: Fiberglass.
 - 3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
- O. Cabinets:
 - 1. NEMA 250, Type 1 Type 3R galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
 - 2. Hinged door in front cover with flush latch and concealed hinge.
 - 3. Key latch to match panelboards.
 - 4. Metal barriers to separate wiring of different systems and voltage.
 - 5. Accessory feet where required for freestanding equipment.
 - 6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.6 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

- A. General Requirements for Handholes and Boxes:
 - 1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
 - 2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. NewBasis.
 - d. Oldcastle Precast, Inc.
 - e. Quazite: Hubbell Power Systems, Inc.
 - f. Synertech Moulded Products.
 - 2. Standard: Comply with SCTE 77.
 - 3. Configuration: Designed for flush burial with integral closed bottom unless otherwise indicated.
 - 4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
 - 5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 - 6. Cover Legend: Molded lettering, "ELECTRIC."

7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
8. Handholes 12 Inches Wide by 24 Inches Long and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.7 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

- A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
 1. Tests of materials shall be performed by an independent testing agency.
 2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
 3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012 and traceable to NIST standards.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below unless otherwise indicated:
 1. Exposed Conduit: GRC IMC.
 2. Concealed Conduit, Aboveground: GRC IMC.
 3. Underground Conduit: RNC, Type EPC-40-PVC, direct buried.
 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
 5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
- B. Indoors: Apply raceway products as specified below unless otherwise indicated:
 1. Exposed, Not Subject to Physical Damage: EMT.
 2. Exposed, Not Subject to Severe Physical Damage: EMT.
 3. Exposed and Subject to Severe Physical Damage: GRC IMC. Raceway locations include the following:
 - a. Loading dock.
 - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
 - c. Mechanical rooms.
 4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
 6. Damp or Wet Locations: GRC.

7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.
- C. Minimum Raceway Size: 3/4-inch trade size.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
 1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
 3. EMT: Use setscrew or compression, cast-metal fittings. Comply with NEMA FB 2.10.
 4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
- E. Install surface raceways only where indicated on Drawings.
- F. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.2 INSTALLATION

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- B. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.
- C. Do not install raceways or electrical items on any "explosion-relief" walls or rotating equipment.
- D. Do not fasten conduits onto the bottom side of a metal deck roof.
- E. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- F. Complete raceway installation before starting conductor installation.

- G. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- H. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.
- I. Make bends in raceway using large-radius preformed ells. Field bending shall be according to NFPA 70 minimum radii requirements. Use only equipment specifically designed for material and size involved.
- J. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- K. Support conduit within 12 inches of enclosures to which attached.
- L. Raceways Embedded in Slabs:
 - 1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot intervals.
 - 2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
 - 3. Arrange raceways to keep a minimum of 1 inch of concrete cover in all directions.
 - 4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
 - 5. Change from ENT to GRC before rising above floor.
- M. Stub-Ups to Above Recessed Ceilings:
 - 1. Use EMT, IMC, or RMC for raceways.
 - 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- N. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
- O. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.
- P. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

- Q. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.
- R. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- S. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.
- T. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.
- U. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.
- V. Surface Raceways:
 - 1. Install surface raceway with a minimum 2-inch radius control at bend points.
 - 2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.
- W. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.
- X. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:
 - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - 2. Where an underground service raceway enters a building or structure.
 - 3. Conduit extending from interior to exterior of building.
 - 4. Conduit extending into pressurized duct and equipment.
 - 5. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
 - 6. Where otherwise required by NFPA 70.

- Y. Comply with manufacturer's written instructions for solvent welding RNC and fittings.
- Z. Expansion-Joint Fittings:
 - 1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
 - 2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
 - d. Attics: 135 deg F temperature change.
 - 3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
 - 4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
 - 5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- AA. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
 - 1. Use LFMC in damp or wet locations subject to severe physical damage.
 - 2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.
- BB. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.
- CC. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

- DD. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel. Where back-to back box installations cannot be avoided in the same framing cavity, provide "putty pads" to seal each box in the same cavity to wall and cover cutouts.
- EE. Locate boxes so that cover or plate will not span different building finishes.
- FF. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
- GG. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
- HH. Set metal floor boxes level and flush with finished floor surface. Boxes that fully penetrate demising floor-ceiling assembly structural floor slabs shall be sealed with putty pads or appropriate fire stop on bottom of penetration.
- II. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe less than 6 inches in nominal diameter.
2. Install backfill as specified in Section 312000 "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."
4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through floor unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete for a minimum of 12 inches on each side of the coupling.

- b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.
- 6. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.
- D. Install handholes with bottom below frost line, below grade.
- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables but short enough to preserve adequate working clearances in enclosure.
- F. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.6 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

SECTION 260536 - CABLE TRAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Ladder cable tray.
 - 2. Cable tray accessories.
 - 3. Warning signs.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include data indicating dimensions and finishes for each type of cable tray indicated.
- B. Shop Drawings: For each type of cable tray.
 - 1. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
 - a. Vertical and horizontal offsets and transitions.
 - b. Clearances for access above and to sides of cable trays.
 - c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
 - d. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design cable tray supports and seismic bracing.

2.2 GENERAL REQUIREMENTS FOR CABLE TRAY

- A. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.
 - 1. Source Limitations: Obtain cable trays and components from single manufacturer.
- B. Sizes and Configurations: See the Cable Tray Schedule on Drawings for specific requirements for types, materials, sizes, and configurations.
- C. Structural Performance: See articles on individual cable tray types for specific values for the following parameters:
 - 1. Uniform Load Distribution: Capable of supporting a uniformly distributed load on the indicated support span when supported as a simple span and tested according to NEMA VE 1.
 - 2. Concentrated Load: A load applied at midpoint of span and centerline of tray.
 - 3. Load and Safety Factors: Applicable to both side rails and rung capacities.

2.3 LADDER CABLE TRAY

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. B-line, an Eaton business.
 - 2. Chalfant Manufacturing Company.
 - 3. Cope Cable Tray; A Part of Atkore International.
 - 4. MonoSystems, Inc.
 - 5. MP Husky USA Cable Tray & Cable Bus.
 - 6. Niedax Inc.
 - 7. Thomas & Betts Corporation; A Member of the ABB Group.
- B. Description:
 - 1. Configuration: Two longitudinal side rails with transverse rungs swaged or welded to side rails, complying with NEMA VE 1.

2. Width: 12 inches unless otherwise indicated on Drawings.
3. Minimum Usable Load Depth: 4 inches.
4. Straight Section Lengths: 10 feet, except where shorter lengths are required to facilitate tray assembly.
5. Rung Spacing: 12 inches o.c.
6. Radius-Fitting Rung Spacing: 9 inches at center of tray's width.
7. Minimum Cable-Bearing Surface for Rungs: 7/8-inch width with radius edges.
8. No portion of the rungs shall protrude below the bottom plane of side rails.
9. Structural Performance of Each Rung: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb concentrated load, when tested according to NEMA VE 1.
10. Fitting Minimum Radius: 12 inches.
11. Class Designation: Comply with NEMA VE 1, Class 8A.
12. Splicing Assemblies: Bolted type using serrated flange locknuts.
13. Splice-Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

C. Materials and Finishes:

1. Steel:
 - a. Straight Section and Fitting Side Rails and Rungs: Steel complies with the minimum mechanical properties of ASTM A 1011/A 1011M, SS, Grade 33.
 - b. Steel Tray Splice Plates: ASTM A 1011/A 1011M, HSLAS, Grade 50, Class 1.
 - c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A 510/A 510M, Grade 1008.
 - d. Finish: Hot-dipped galvanized after fabrication, complying with ASTM A123/A123 M, Class B2.
 - 1) Hardware: Chromium-zinc plated, ASTM F 1136.
 - e. Finish: Hot-dipped galvanized after fabrication, complying with ASTM A 653/A 653M, G90.
 - 1) Hardware: Chromium-zinc plated, ASTM F 1136.
 - f. Finish: Electrogalvanized after fabrication, complying with ASTM B 633.
 - 1) Hardware: Galvanized, ASTM B 633.
 - g. Finish: Powder-coat enamel paint.
 - 1) Powder-Coat Enamel: Cable tray manufacturer's recommended primer and corrosion-inhibiting treatment, with factory-applied powder-coat paint.
 - 2) Epoxy-Resin Prime Coat: Cold-curing epoxy primer, MPI# 101.
 - 3) Epoxy-Resin Topcoat: Epoxy, cold-cured gloss, MPI# 77.
 - 4) Hardware: Chromium-zinc plated, ASTM F 1136.
 - h. Finish: Factory-standard primer, ready for field painting, with chromium-zinc-plated hardware according to ASTM F 1136.
 - i. Finish: Black oxide finish for support accessories and miscellaneous hardware according to ASTM D 769.

2.4 CABLE TRAY ACCESSORIES

- A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.
- B. Barrier Strips: Same materials and finishes as for cable tray.
- C. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.5 WARNING SIGNS

- A. Lettering: 1-1/2-inch- high, black letters on yellow background, with legend "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL."
- B. Comply with Section 260553 "Identification for Electrical Systems."

2.6 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect cable trays according to NEMA VE 1.

PART 3 - EXECUTION

3.1 CABLE TRAY INSTALLATION

- A. Install cable tray and support systems according to NEMA VE 2.
- B. Install cable tray as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.
- C. Install cable tray, so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.
- D. Remove burrs and sharp edges from cable trays.

- E. Join aluminum cable tray with splice plates; use four square-neck carriage bolts and locknuts.
- F. Fasten cable tray supports to building structure.
- G. Design fasteners and supports to carry cable tray, cables, and a concentrated load of 200 lb. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems."
- H. Place supports, so that spans do not exceed maximum spans on schedules, and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of tray rungs.
- I. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.
- J. Support assembly to prevent twisting from eccentric loading.
- K. Install center-hung supports for single-rail trays designed for 60 versus 40 percent eccentric loading condition, with a safety factor of 3.
- L. Do not install more than one cable tray splice between supports.
- M. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.
- N. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed recommended dimensions. Space connectors and set gaps according to applicable standard.
- O. Make changes in direction and elevation using manufacturer's recommended fittings.
- P. Make cable tray connections using manufacturer's recommended fittings.
- Q. Seal penetrations through fire and smoke barriers. Comply with requirements in Section 078413 "Penetration Firestopping."

- R. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.
- S. Install cable trays with enough workspace to permit access for installing cables.
- T. Install barriers to separate cables of different systems, such as power, communications, and data processing, or of different insulation levels, such as 600, 5000, and 15 000 V.
- U. Install permanent covers, if used, after installing cable.
- V. Clamp covers on cable trays installed outdoors with heavy-duty clamps.
- W. Install warning signs in visible locations on or near cable trays after cable tray installation.

3.2 CABLE TRAY GROUNDING

- A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Cable trays with electrical power conductors shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.
- C. Cable trays with single-conductor power conductors shall be bonded together with a grounding conductor run in the tray along with the power conductors and bonded to the tray at 72-inch intervals. The grounding conductor shall be sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors," and Article 392, "Cable Trays."
- D. When using epoxy- or powder-coat painted cable trays as a grounding conductor, completely remove coating at all splice contact points or ground connector attachment. After completing splice-to-grounding-bolt attachment, repair the coated surfaces with coating materials recommended by cable tray manufacturer.
- E. Bond cable trays to power source for cables contained within with bonding conductors sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors."

3.3 CABLE INSTALLATION

- A. Install cables only when each cable tray run has been completed and inspected.
- B. Fasten cables on horizontal runs with cable clamps or cable ties. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.
- C. Fasten cables on vertical runs to cable trays every 18 inches.
- D. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables independent of the enclosure. The cable length between cable trays or between cable tray and enclosure shall be no more than 72 inches.
- E. Tie mineral-insulated cables down every 36 inches where required to provide a two-hour fire rating and every 72 inches elsewhere.
- F. In existing construction, remove inactive or dead cables from cable trays.

3.4 CONNECTIONS

- A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.
- B. Connect raceways to cable trays according to requirements in NEMA VE.

3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.
 - 2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
 - 3. Verify that the number, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications or data-processing circuits are separated from power circuits by barriers or are installed in separate cable trays.

4. Verify that there are no intruding items, such as pipes, hangers, or other equipment, in the cable tray.
5. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
7. Check for improperly sized or installed bonding jumpers.
8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.

B. Prepare test and inspection reports.

3.6 PROTECTION

A. Protect installed cable trays and cables.

1. Install temporary protection for cables in open trays to safeguard exposed cables against falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.
2. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
3. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

END OF SECTION

SECTION 260543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Metal conduits and fittings, including GRC and PVC-coated steel conduit.
 - 2. Rigid nonmetallic duct.
 - 3. Duct accessories.
 - 4. Precast concrete handholes.
 - 5. Polymer concrete handholes and boxes with polymer concrete cover.

1.3 DEFINITIONS

- A. Direct Buried: Duct or a duct bank that is buried in the ground, without any additional casing materials such as concrete.
- B. Duct: A single duct or multiple ducts. Duct may be either installed singly or as component of a duct bank.
- C. Duct Bank:
 - 1. Two or more ducts installed in parallel, with or without additional casing materials.
 - 2. Multiple duct banks.
- D. GRC: Galvanized rigid (steel) conduit.
- E. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include duct-bank materials, including spacers and miscellaneous components.
 - 2. Include duct, conduits, and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
 - 3. Include accessories for manholes, handholes, boxes.
 - 4. Include underground-line warning tape.
- B. Shop Drawings:
 - 1. Factory-Fabricated Handholes and Boxes Other Than Precast Concrete:
 - a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
 - b. Include duct entry provisions, including locations and duct sizes.
 - c. Include cover design.
 - d. Include grounding details.
 - e. Include dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: For duct and duct bank. Show duct profiles and coordination with other utilities and underground structures.
 - 1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
 - 2. Drawings shall be signed and sealed by a qualified professional engineer.
- B. Qualification Data: For professional engineer and testing agency responsible for testing nonconcrete handholes and boxes.
- C. Product Certificates: For concrete and steel used in precast concrete handholes, as required by ASTM C 858.
- D. Source quality-control reports.
- E. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

1.7 FIELD CONDITIONS

- A. Ground Water: Assume ground-water level is at grade level unless a lower water table is noted on Drawings.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND FITTINGS

- A. GRC: Comply with ANSI C80.1 and UL 6.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AFC Cable Systems; a part of Atkore International.
 - 2. Allied Tube & Conduit; a part of Atkore International.
 - 3. Anamet Electrical, Inc.
 - 4. Calconduit.
 - 5. Electri-Flex Company.
 - 6. FSR Inc.
 - 7. Korkap.
 - 8. NEC, Inc.
 - 9. Opti-Com Manufacturing Network, Inc (OMNI).
 - 10. O-Z/Gedney; a brand of Emerson Industrial Automation.
 - 11. Perma-Cote.
 - 12. Picoma Industries, Inc.
 - 13. Plasti-Bond.
 - 14. Republic Conduit.
 - 15. Southwire Company.
 - 16. Thomas & Betts Corporation; A Member of the ABB Group.
 - 17. Topaz Electric; a division of Topaz Lighting Corp.
 - 18. Western Tube and Conduit Corporation.
 - 19. Wheatland Tube Company.
- C. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

2.2 RIGID NONMETALLIC DUCT

- A. Underground Plastic Utilities Duct: Type EPC-40-PVC RNC, complying with NEMA TC 2 and UL 651, with matching fittings complying with NEMA TC 3 by same manufacturer as duct.

- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ARNCO Corp.
 - 2. Beck Manufacturing.
 - 3. CANTEX INC.
 - 4. CertainTeed Corporation.
 - 5. Condux International, Inc.
 - 6. Crown Line Plastics.
 - 7. ElecSys, Inc.
 - 8. Electri-Flex Company.
 - 9. Endot Industries Inc.
 - 10. IPEX USA LLC.
 - 11. Lamson & Sessions.
 - 12. Manhattan/CDT.
 - 13. National Pipe & Plastics.
 - 14. Opti-Com Manufacturing Network, Inc (OMNI).
 - 15. Spiraduct/AFC Cable Systems, Inc.
- C. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.
- D. Solvents and Adhesives: As recommended by conduit manufacturer.

2.3 DUCT ACCESSORIES

- A. Duct Spacers: Factory-fabricated, rigid, PVC interlocking spacers; sized for type and size of duct with which used, and selected to provide minimum duct spacing indicated while supporting duct during concreting or backfilling.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit; a part of Atkore International.
 - b. CANTEX INC.
 - c. Carlon; a brand of Thomas & Betts Corporation.
 - d. IPEX USA LLC.
 - e. PenCell Plastics.
 - f. Underground Devices, Inc.
- B. Underground-Line Warning Tape: Comply with requirements for underground-line warning tape specified in Section 260553 "Identification for Electrical Systems."

2.4 POLYMER CONCRETE HANDHOLES AND BOXES WITH POLYMER CONCRETE COVER

- A. Description: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Armorcast Products Company.
 - 2. MacLean Highline.
 - 3. NewBasis.
 - 4. Oldcastle Enclosure Solutions.
 - 5. Quazite: Hubbell Power Systems, Inc.
- C. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.
- D. Color: Gray.
- E. Configuration: Units shall be designed for flush burial and have integral closed bottom unless otherwise indicated.
- F. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
- G. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- H. Cover Legend: Molded lettering, "ELECTRIC."
- I. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
- J. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering duct for secure, fixed installation in enclosure wall.
- K. Handholes 12 inches wide by 24 inches long and larger shall have factory-installed inserts for cable racks and pulling-in irons.

2.5 SOURCE QUALITY CONTROL

- A. Test and inspect precast concrete utility structures according to ASTM C 1037.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Coordinate layout and installation of duct, duct bank, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.

3.2 UNDERGROUND DUCT APPLICATION

- A. Duct for Electrical Cables More Than 600 V: Type EPC-40-PVC RNC, direct buried unless otherwise indicated.
- B. Duct for Electrical Feeders 600 V and Less: Type EPC-40-PVC RNC, direct buried unless otherwise indicated.
- C. Duct for Electrical Feeders 600 V and Less: Type EPC-40-PVC RNC, direct-buried unless otherwise indicated.
- D. Duct for Electrical Branch Circuits: Type EPC-40-PVC RNC, direct-buried unless otherwise indicated.
- E. Bored Underground Duct: Type EPEC-40-HDPE unless otherwise indicated.
- F. Stub-ups: RNC.

3.3 UNDERGROUND ENCLOSURE APPLICATION

- A. Handholes and Boxes for 600 V and Less:
 - 1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, H-20 structural load rating.

2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 structural load rating.
3. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Precast concrete, AASHTO HB 17, H-10 structural load rating.
4. Units Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf vertical loading.
5. Cover design load shall not exceed the design load of the handhole or box.

3.4 EARTHWORK

- A. Excavation and Backfill: Comply with Section 312000 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.
- B. Restoration: Replace area after construction vehicle traffic in immediate area is complete.
- C. Restore surface features at areas disturbed by excavation, and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
- D. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 329200 "Turf and Grasses" and Section 329300 "Plants."
- E. Cut and patch existing pavement in the path of underground duct, duct bank, and underground structures according to "Cutting and Patching" Article in Section 017300 "Execution."

3.5 DUCT AND DUCT-BANK INSTALLATION

- A. Where indicated on Drawings, install duct, spacers, and accessories into the duct-bank configuration shown. Duct installation requirements in this Section also apply to duct bank.
- B. Install duct according to NEMA TCB 2.

- C. Slope: Pitch duct a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope duct from a high point between two manholes, to drain in both directions.
- D. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 12.5 feet, both horizontally and vertically, at other locations unless otherwise indicated.
 - 1. Duct shall have maximum of two 90 degree bends or the total of all bends shall be no more 180 degrees between pull points.
- E. Joints: Use solvent-cemented joints in duct and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent duct do not lie in same plane.
- F. Installation Adjacent to High-Temperature Steam Lines: Where duct is installed parallel to underground steam lines, perform calculations showing the duct will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated to rise above 40 deg C, and anywhere the duct crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.
- G. Terminator Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use manufactured, cast-in-place duct terminators, with entrances into structure spaced approximately 6 inches o.c. for 4-inch duct, and vary proportionately for other duct sizes.
 - 1. Begin change from regular spacing to terminator spacing 10 feet from the terminator, without reducing duct line slope and without forming a trap in the line.
 - 2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line duct with calculated expansion of more than 3/4 inch.
- H. Building Wall Penetrations: Make a transition from underground duct to GRC at least 10 feet outside the building wall, without reducing duct line slope away from the building and without forming a trap in the line. Use fittings manufactured for RNC-to-GRC transition. Install GRC penetrations of building walls as specified in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."
- I. Sealing: Provide temporary closure at terminations of duct with pulled cables. Seal spare duct at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.
- J. Pulling Cord: Install 200-lbf- test nylon cord in empty ducts.

K. Direct-Buried Duct and Duct Bank:

1. Excavate trench bottom to provide firm and uniform support for duct. Comply with requirements in Section 312000 "Earth Moving" for preparation of trench bottoms for pipes less than 6 inches in nominal diameter.
2. Width: Excavate trench 12 inches wider than duct on each side.
3. Width: Excavate trench 3 inches wider than duct on each side.
4. Depth: Install top of duct at least 36 inches below finished grade unless otherwise indicated.
5. Set elevation of bottom of duct bank below frost line.
6. Support ducts on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
7. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four spacers per 20 feet of duct. Place spacers within 24 inches of duct ends. Stagger spacers approximately 6 inches between tiers. Secure spacers to earth and to ducts to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
8. Install duct with a minimum of 3 inches between ducts for like services and 6 inches between power and communications duct.
9. Elbows: Install manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct direction unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
10. Install manufactured GRC elbows for stub-ups, at building entrances, and at changes of direction in duct.
 - a. Couple RNC duct to GRC with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
 - b. Stub-ups to Outdoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.
 - 1) Stub-ups shall be minimum 4 inches above finished floor and minimum 3 inches from conduit side to edge of slab
 - c. Stub-ups to Indoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of wall. Install insulated grounding bushings on terminations at equipment.
 - 1) Stub-ups shall be minimum 4 inches above finished floor and no less than 3 inches from conduit side to edge of slab
11. After installing first tier of duct, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inches over duct and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction. Comply with requirements in Section 312000 "Earth Moving" for installation of backfill materials.
 - a. Place minimum 3 inches of sand as a bed for duct. Place sand to a minimum of 6 inches above top level of duct.

- b. Place minimum 6 inches of engineered fill above concrete encasement of duct.
- L. Underground-Line Warning Tape: Bury conducting underground line specified in Section 260553 "Identification for Electrical Systems" no less than 12 inches above all concrete-encased duct and duct banks and approximately 12 inches below grade. Align tape parallel to and within 3 inches of centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

3.6 INSTALLATION OF CONCRETE HANDHOLES, AND BOXES

- A. Precast Concrete Handhole Installation:
 - 1. Comply with ASTM C 891 unless otherwise indicated.
 - 2. Install units level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances.
 - 3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- B. Dampproofing: Apply dampproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Dampproofing materials and installation are specified in Section 071113 "Bituminous Dampproofing." After ducts are connected and grouted, and before backfilling, dampproof joints and connections, and touch up abrasions and scars. Dampproof exterior of manhole chimneys after mortar has cured at least three days.
- C. Hardware: Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated.
- D. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.
- E. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches for manholes and 2 inches for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

3.7 GROUNDING

- A. Ground underground ducts and utility structures according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.8 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Demonstrate capability and compliance with requirements on completion of installation of underground duct, duct bank, and utility structures.
 - 2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum 12-inch-long mandrel equal to duct size minus 1/4 inch. If obstructions are indicated, remove obstructions and retest.
 - 3. Test handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Correct deficiencies and retest as specified above to demonstrate compliance.
- C. Prepare test and inspection reports.

3.9 CLEANING

- A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of duct until duct cleaner indicates that duct is clear of dirt and debris. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

END OF SECTION

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

1. Color and legend requirements for raceways, conductors, and warning labels and signs.
2. Labels.
3. Bands and tubes.
4. Tapes and stencils.
5. Tags.
6. Signs.
7. Cable ties.
8. Paint for identification.
9. Fasteners for labels and signs.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.
- B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.
- C. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.
- D. Delegated-Design Submittal: For arc-flash hazard study.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Comply with ASME A13.1.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Comply with NFPA 70E and Section 260573.19 "Arc-Flash Hazard Analysis" requirements for arc-flash warning labels.
- F. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.
- G. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 - 1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

- A. Raceways and Cables Carrying Circuits at 600 V or Less:
 - 1. Black letters on an orange field.
 - 2. Legend: Indicate voltage and system or service type.
- B. Color-Coding for Phase- and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded service feeder and branch-circuit conductors.
 - 1. Color shall be factory applied or field applied for sizes larger than No. 8 AWG if authorities having jurisdiction permit.
 - 2. Colors for 208/120-V Circuits:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 - d. Color for Neutral: White.
 - e. Color for Equipment Grounds: Green.
 - 3. Colors for 480/277-V Circuits:
 - a. Phase A: Brown.

- b. Phase B: Orange.
- c. Phase C: Yellow.
- d. Color for Neutral: Grey.
- e. Color for Equipment Grounds: Green.

C. Warning Label Colors:

- 1. Identify system voltage with black letters on an orange background.

D. Warning labels and signs shall include, but are not limited to, the following legends:

- 1. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

E. Equipment Identification Labels:

- 1. Black letters on a white field.

2.3 TAPES AND STENCILS

A. Floor Marking Tape: 2-inch- wide, 5-mil pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Carlton Industries, LP.
 - b. Seton Identification Products.

B. Underground-Line Warning Tape:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Ideal Industries, Inc.
 - c. LEM Products Inc.
 - d. Marking Services, Inc.
 - e. Reef Industries, Inc.
 - f. Seton Identification Products.
- 2. Tape:
 - a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
 - b. Printing on tape shall be permanent and shall not be damaged by burial operations.
 - c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.
- 3. Color and Printing:

- a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
 - b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE".
 - c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".
- C. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.

2.4 SIGNS

- A. Laminated Acrylic or Melamine Plastic Signs:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Carlton Industries, LP.
 - c. emedco.
 - d. Marking Services, Inc.
 - 2. Engraved legend.
 - 3. Thickness:
 - a. For signs up to 20 sq. in., minimum 1/16 inch thick.
 - b. For signs larger than 20 sq. in., 1/8 inch thick.
 - c. Engraved legend with black letters on white face.
 - d. Punched or drilled for mechanical fasteners with 1/4-inch grommets in corners for mounting.
 - e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.5 CABLE TIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. HellermannTyton.
 - 2. Ideal Industries, Inc.
 - 3. Marking Services, Inc.
 - 4. Panduit Corp.
- B. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.
 - 1. Minimum Width: 3/16 inch.
 - 2. Tensile Strength at 73 Deg F according to ASTM D638: 7000 psi.
 - 3. UL 94 Flame Rating: 94V-0.
 - 4. Temperature Range: Minus 50 to plus 284 deg F.
 - 5. Color: Black.

2.6 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

- A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.
- B. Install identifying devices before installing acoustical ceilings and similar concealment.
- C. Verify identity of each item before installing identification products.
- D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- E. Apply identification devices to surfaces that require finish after completing finish work.
- F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.
- G. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.
- H. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
- I. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.
- J. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:
1. "EMERGENCY POWER."
 2. "POWER."
 3. "UPS."
 4. "COMMUNICATIONS."
 5. "FIRE ALARM."
 6. "ACCESS CONTROL"
 7. "CCTV."
- K. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's written instructions.
- L. Underground Line Warning Tape:
1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench exceeds 16 inches overall.
 2. Limit use of underground-line warning tape to direct-buried cables.
 3. Install underground-line warning tape for direct-buried cables and cables in raceways.
- M. Laminated Acrylic or Melamine Plastic Signs:
1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
 2. Unless otherwise indicated, provide a single line of text with 1/2-inch- high letters on 1-1/2-inch- high sign; where two lines of text are required, use labels 2 inches high.
- N. Cable Ties: General purpose, for attaching tags, except as listed below:

3.3 IDENTIFICATION SCHEDULE

- A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.
- B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.
- C. Accessible Raceways, Armored and Metal-Clad Cables, More Than 600 V: Vinyl wraparound labels.
 - 1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- D. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive vinyl tape applied in bands.
 - 1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- E. Accessible Fittings for Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive labels containing the wiring system legend and system voltage. System legends shall be as follows:
 - 1. "EMERGENCY POWER."
 - 2. "POWER."
 - 3. "UPS."
- F. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use vinyl wraparound labels to identify the phase.
 - 1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- G. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.
- H. Workspace Indication: Apply floor marking tape to finished surfaces. Show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

- I. Instructional Signs: Self-adhesive labels, including the color code for grounded and ungrounded conductors.
- J. Arc Flash Warning Labeling: Self-adhesive labels.
- K. Equipment Identification Labels:
 - 1. Indoor Equipment: Laminated acrylic or melamine plastic sign.
 - 2. Outdoor Equipment: Stenciled legend 1 inch high.
 - 3. Equipment to Be Labeled:
 - a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be in the form of a engraved, laminated acrylic or melamine label.
 - b. Enclosures and electrical cabinets.
 - c. Access doors and panels for concealed electrical items.
 - d. Switchgear.
 - e. Switchboards.
 - f. Emergency system boxes and enclosures.
 - g. Enclosed switches.
 - h. Enclosed circuit breakers.
 - i. Enclosed controllers.
 - j. Variable-speed controllers.
 - k. Power-transfer equipment.
 - l. Contactors.
 - m. Remote-controlled switches, dimmer modules, and control devices.
 - n. Power-generating units.
 - o. Monitoring and control equipment.
 - p. UPS equipment.

END OF SECTION

SECTION 260573.13 - SHORT-CIRCUIT STUDIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes a computer-based, fault-current study to determine the minimum interrupting capacity of circuit protective devices.

1.3 DEFINITIONS

- A. Field Adjusting Agency: An independent electrical testing agency with full-time employees and the capability to adjust devices and conduct testing indicated and that is a member company of NETA.
- B. One-Line Diagram: A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
- C. Power System Analysis Software Developer: An entity that commercially develops, maintains, and distributes computer software used for power system studies.
- D. Power Systems Analysis Specialist: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located.
- E. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion of the circuit from the system.
- F. SCCR: Short-circuit current rating.

- G. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

- H. Single-Line Diagram: See "One-Line Diagram."

1.4 ACTION SUBMITTALS

A. Product Data:

1. For computer software program to be used for studies.
2. Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.
 - a. Short-circuit study input data, including completed computer program input data sheets.
 - b. Short-circuit study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.
 - 1) Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.
 - 2) Revised one-line diagram, reflecting field investigation results and results of short-circuit study.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data:

1. For Power Systems Analysis Software Developer.
2. For Power System Analysis Specialist.
3. For Field Adjusting Agency.

- B. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:

1. For overcurrent protective devices to include in emergency, operation, and maintenance manuals.
2. The following are from the Short-Circuit Study Report:
 - a. Final one-line diagram.
 - b. Final Short-Circuit Study Report.

- c. Short-circuit study data files.
- d. Power system data.

1.7 QUALITY ASSURANCE

- A. Study shall be performed using commercially developed and distributed software designed specifically for power system analysis.
- B. Software algorithms shall comply with requirements of standards and guides specified in this Section.
- C. Manual calculations are unacceptable.
 - 1. Power System Analysis Software Qualifications: Computer program shall be designed to perform short-circuit studies or have a function, component, or add-on module designed to perform short-circuit studies.
 - 2. Computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
- D. Power Systems Analysis Specialist Qualifications: Professional engineer licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
- E. Short-Circuit Study Certification: Short-Circuit Study Report shall be signed and sealed by Power Systems Analysis Specialist.
- F. Field Adjusting Agency Qualifications:
 - 1. Employer of a NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification responsible for all field adjusting of the Work.
 - 2. A member company of NETA.
 - 3. Acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE DEVELOPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. CGI CYME.
 - 2. EDSA Micro Corporation.
 - 3. ESA Inc.

4. Operation Technology, Inc.
 5. Power Analytics, Corporation.
 6. SKM Systems Analysis, Inc.
- B. Comply with IEEE 399 and IEEE 551.
1. Analytical features of power systems analysis software program shall have capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.
- C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output.

2.2 SHORT-CIRCUIT STUDY REPORT CONTENTS

- A. Executive summary of study findings.
- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
- C. One-line diagram of modeled power system, showing the following:
1. Protective device designations and ampere ratings.
 2. Conductor types, sizes, and lengths.
 3. Transformer kilovolt ampere (kVA) and voltage ratings.
 4. Motor and generator designations and kVA ratings.
 5. Switchgear, switchboard, motor-control center, and panelboard designations and ratings.
 6. Derating factors and environmental conditions.
 7. Any revisions to electrical equipment required by the study.
- D. Comments and recommendations for system improvements or revisions in a written document, separate from one-line diagram.
- E. Protective Device Evaluation:
1. Evaluate equipment and protective devices and compare to available short-circuit currents. Verify that equipment withstand ratings exceed available short-circuit current at equipment installation locations.
 2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
 3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
 4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in standards to 1/2-cycle symmetrical fault current.

5. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

F. Short-Circuit Study Input Data:

1. One-line diagram of system being studied.
2. Power sources available.
3. Manufacturer, model, and interrupting rating of protective devices.
4. Conductors.
5. Transformer data.

G. Short-Circuit Study Output Reports:

1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. Equivalent impedance.
2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated symmetrical fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. Calculated asymmetrical fault currents:
 - 1) Based on fault-point X/R ratio.
 - 2) Based on calculated symmetrical value multiplied by 1.6.
 - 3) Based on calculated symmetrical value multiplied by 2.7.
3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated symmetrical fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. No AC Decrement (NACD) ratio.
 - e. Equivalent impedance.
 - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
 - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

PART 3 - EXECUTION

3.1 POWER SYSTEM DATA

- A. Obtain all data necessary for conduct of the study.

1. Verify completeness of data supplied on one-line diagram. Call any discrepancies to Architect's attention.
 2. For equipment included as Work of this Project, use characteristics submitted under provisions of action submittals and information submittals for this Project.
- B. Gather and tabulate the required input data to support the short-circuit study. Comply with requirements in Section 017839 "Project Record Documents" for recording circuit protective device characteristics. Record data on a Record Document copy of one-line diagram. Comply with recommendations in IEEE 551 as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification. Data include, but are not limited to, the following:
1. Product Data for Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
 2. Obtain electrical power utility impedance at the service.
 3. Power sources and ties.
 4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
 5. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
 6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
 7. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
 8. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
 9. Motor horsepower and NEMA MG 1 code letter designation.
 10. Conductor sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
 11. Derating factors.

3.2 SHORT-CIRCUIT STUDY

- A. Perform study following the general study procedures contained in IEEE 399.
- B. Calculate short-circuit currents according to IEEE 551.
- C. Base study on device characteristics supplied by device manufacturer.
- D. Extent of electrical power system to be studied is indicated on Drawings.

- E. Begin short-circuit current analysis at the service, extending down to system overcurrent protective devices as follows:
 - 1. To normal system low-voltage load buses where fault current is 10 kA or less.
 - 2. Exclude equipment rated 240 V ac or less when supplied by a single transformer rated less than 125 kVA.
- F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- G. Include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase ac systems. Also account for the fault-current dc decrement to address asymmetrical requirements of interrupting equipment.
- H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and a single line-to-ground fault at each equipment indicated on one-line diagram.
 - 1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
- I. Include in the report identification of any protective device applied outside its capacity.

END OF SECTION

SECTION 260573.16 - COORDINATION STUDIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.
 - 1. Study results shall be used to determine coordination of series-rated devices.

1.3 DEFINITIONS

- A. Field Adjusting Agency: An independent electrical testing agency with full-time employees and the capability to adjust devices and conduct testing indicated and that is a member company of NETA.
- B. One-Line Diagram: A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
- C. Power System Analysis Software Developer: An entity that commercially develops, maintains, and distributes computer software used for power system studies.
- D. Power System Analysis Specialist: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located.
- E. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion of the circuit from the system.
- F. SCCR: Short-circuit current rating.

- G. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

- H. Single-Line Diagram: See "One-Line Diagram."

1.4 ACTION SUBMITTALS

A. Product Data:

1. For computer software program to be used for studies.
2. Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.
 - a. Coordination-study input data, including completed computer program input data sheets.
 - b. Study and equipment evaluation reports.
3. Overcurrent protective device coordination study report; signed, dated, and sealed by a qualified professional engineer.
 - a. Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data:

1. For Power System Analysis Software Developer.
2. For Power Systems Analysis Specialist.
3. For Field Adjusting Agency.

- B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For overcurrent protective devices to include in emergency, operation, and maintenance manuals.

1. The following are from the Coordination Study Report:
 - a. Final one-line diagram.
 - b. Final protective device coordination study.
 - c. Coordination study data files.
 - d. List of all protective device settings.
 - e. Time-current coordination curves.

- f. Power system data.

1.7 QUALITY ASSURANCE

- A. Studies shall be performed using commercially developed and distributed software designed specifically for power system analysis.
- B. Software algorithms shall comply with requirements of standards and guides specified in this Section.
- C. Manual calculations are unacceptable.
- D. Power System Analysis Software Qualifications:
 - 1. Computer program shall be designed to perform coordination studies or have a function, component, or add-on module designed to perform coordination studies.
 - 2. Computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
- E. Power Systems Analysis Specialist Qualifications: Professional engineer licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
- F. Field Adjusting Agency Qualifications:
 - 1. Employer of a NETA ETT-Certified Technician Level III responsible for all field adjusting of the Work.
 - 2. A member company of NETA.
 - 3. Acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE DEVELOPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. CGI CYME.
 - 2. EDSA Micro Corporation.
 - 3. ESA Inc.
 - 4. Operation Technology, Inc.
 - 5. Power Analytics, Corporation.

6. SKM Systems Analysis, Inc.
- B. Comply with IEEE 242 and IEEE 399.
- C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.
- D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.
 1. Optional Features:
 - a. Arcing faults.
 - b. Simultaneous faults.
 - c. Explicit negative sequence.
 - d. Mutual coupling in zero sequence.

2.2 COORDINATION STUDY REPORT CONTENTS

- A. Executive summary of study findings.
- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
- C. One-line diagram of modeled power system, showing the following:
 1. Protective device designations and ampere ratings.
 2. Conductor types, sizes, and lengths.
 3. Transformer kilovolt ampere (kVA) and voltage ratings.
 4. Motor and generator designations and kVA ratings.
 5. Switchgear, switchboard, motor-control center, and panelboard designations.
 6. Any revisions to electrical equipment required by the study.
 7. Study Input Data: As described in "Power System Data" Article.
 - a. Short-Circuit Study Output: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260573.13 "Short-Circuit Studies."
- D. Protective Device Coordination Study:
 1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.
 - a. Phase and Ground Relays:
 - 1) Device tag.

- 2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
 - 3) Recommendations on improved relaying systems, if applicable.
 - b. Circuit Breakers:
 - 1) Adjustable pickups and time delays (long time, short time, and ground).
 - 2) Adjustable time-current characteristic.
 - 3) Adjustable instantaneous pickup.
 - 4) Recommendations on improved trip systems, if applicable.
 - c. Fuses: Show current rating, voltage, and class.
- E. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
 1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
 2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
 3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
 4. Plot the following listed characteristic curves, as applicable:
 - a. Power utility's overcurrent protective device.
 - b. Medium-voltage equipment overcurrent relays.
 - c. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
 - d. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
 - e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
 - f. Cables and conductors damage curves.
 - g. Ground-fault protective devices.
 - h. Motor-starting characteristics and motor damage points.
 - i. Generator short-circuit decrement curve and generator damage point.
 - j. The largest feeder circuit breaker in each motor-control center and panelboard.
 5. Maintain selectivity for tripping currents caused by overloads.
 6. Maintain maximum achievable selectivity for tripping currents caused by overloads on series-rated devices.
 7. Provide adequate time margins between device characteristics such that selective operation is achieved.
 8. Comments and recommendations for system improvements.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance of the Work. Devices to be coordinated are indicated on Drawings.
 - 1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.2 POWER SYSTEM DATA

- A. Obtain all data necessary for conduct of the overcurrent protective device study.
 - 1. Verify completeness of data supplied in one-line diagram on Drawings. Call any discrepancies to Architect's attention.
 - 2. For equipment included as Work of this Project, use characteristics submitted under provisions of action submittals and information submittals for this Project.
- B. Gather and tabulate all required input data to support the coordination study. List below is a guide. Comply with recommendations in IEEE 551 for the amount of detail required to be acquired in the field. Field data gathering shall be under direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification. Data include, but are not limited to, the following:
 - 1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
 - 2. Electrical power utility impedance at the service.
 - 3. Power sources and ties.
 - 4. Short-circuit current at each system bus (three phase and line to ground).
 - 5. Full-load current of all loads.
 - 6. Voltage level at each bus.
 - 7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
 - 8. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
 - 9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.

10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
12. Maximum demands from service meters.
13. Busway manufacturer and model designation, current rating, impedance, lengths, size, and conductor material.
14. Motor horsepower and NEMA MG 1 code letter designation.
15. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
16. Medium-voltage cable sizes, lengths, conductor material, cable construction, metallic shield performance parameters, and conduit material (magnetic or nonmagnetic).
17. Data sheets to supplement electrical distribution system one-line diagram, cross-referenced with tag numbers on diagram, showing the following:
 - a. Special load considerations, including starting inrush currents and frequent starting and stopping.
 - b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
 - c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
 - d. Generator thermal-damage curve.
 - e. Ratings, types, and settings of utility company's overcurrent protective devices.
 - f. Special overcurrent protective device settings or types stipulated by utility company.
 - g. Time-current-characteristic curves of devices indicated to be coordinated.
 - h. Manufacturer, frame size, interrupting rating in amperes root mean square (rms) symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
 - i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
 - j. Switchgear, switchboards, motor-control centers, and panelboards ampacity, and SCCR in amperes rms symmetrical.
 - k. Identify series-rated interrupting devices for a condition where the available fault current is greater than the interrupting rating of downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

3.3 COORDINATION STUDY

- A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.
- B. Comply with IEEE 399 for general study procedures.

- C. Base study on device characteristics supplied by device manufacturer.
- D. Extent of electrical power system to be studied is indicated on Drawings.
- E. Begin analysis at the service, extending down to system overcurrent protective devices as follows:
 - 1. To normal system low-voltage load buses where fault current is 10 kA or less.
 - 2. Exclude equipment rated 240 V ac or less when supplied by a single transformer rated less than 125 kVA.
- F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- G. Transformer Primary Overcurrent Protective Devices:
 - 1. Device shall not operate in response to the following:
 - a. Inrush current when first energized.
 - b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
 - c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
 - 2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.
- H. Motor Protection:
 - 1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
 - 2. Select protection for motors served at voltages more than 600 V according to IEEE 620.
- I. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.
- J. Generator Protection: Select protection according to manufacturer's written instructions and to IEEE 242.
- K. Include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase ac

systems. Also account for fault-current dc decrement, to address asymmetrical requirements of interrupting equipment.

- L. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and a single line-to-ground fault at each equipment indicated on one-line diagram.
 - 1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
- M. Protective Device Evaluation:
 - 1. Evaluate equipment and protective devices and compare to short-circuit ratings.
 - 2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.
 - 3. Any application of series-rated devices shall be recertified, complying with requirements in NFPA 70.
 - 4. Include in the report identification of any protective device applied outside its capacity.

3.4 LOAD-FLOW AND VOLTAGE-DROP STUDY

- A. Perform a load-flow and voltage-drop study to determine the steady-state loading profile of the system. Analyze power system performance two times as follows:
 - 1. Determine load flow and voltage drop based on full-load currents obtained in "Power System Data" Article.
 - 2. Determine load flow and voltage drop based on 80 percent of the design capacity of load buses.
 - 3. Prepare load-flow and voltage-drop analysis and report to show power system components that are overloaded, or might become overloaded; show bus voltages that are less than as prescribed by NFPA 70.

3.5 MOTOR-STARTING STUDY

- A. Perform a motor-starting study to analyze the transient effect of system's voltage profile during motor starting. Calculate significant motor-starting voltage profiles and analyze the effects of motor starting on the power system stability.
- B. Prepare the motor-starting study report, noting light flicker for limits proposed by IEEE 141, and voltage sags so as not to affect operation of other utilization equipment on system supplying the motor.

3.6 FIELD ADJUSTING

- A. Adjust relay and protective device settings according to recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of equipment manufacturer under the "Startup and Acceptance Testing" contract portion.
- B. Make minor modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.
- C. Testing and adjusting shall be by a full-time employee of the Field Adjusting Agency, who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification.
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

3.7 DEMONSTRATION

- A. Engage Power Systems Analysis Specialist to train Owner's maintenance personnel in the following:
 - 1. Acquaint personnel in fundamentals of operating the power system in normal and emergency modes.
 - 2. Hand-out and explain the coordination study objectives, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting time-current coordination curves.
 - 3. For Owner's maintenance staff certified as NETA ETT-Certified Technicians Level III or NICET Electrical Power Testing Level III Technicians, teach how to adjust, operate, and maintain overcurrent protective device settings.

END OF SECTION

SECTION 260573.19 - ARC-FLASH HAZARD ANALYSIS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes a computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.3 DEFINITIONS

- A. Field Adjusting Agency: An independent electrical testing agency with full-time employees and the capability to adjust devices and conduct testing indicated and that is a member company of NETA.
- B. One-Line Diagram: A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
- C. Power System Analysis Software Developer: An entity that commercially develops, maintains, and distributes computer software used for power system studies.
- D. Power Systems Analysis Specialist: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located.
- E. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.
- F. SCCR: Short-circuit current rating.

- G. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.
- H. Single-Line Diagram: See "One-Line Diagram."

1.4 ACTION SUBMITTALS

- A. Product Data: For computer software program to be used for studies.
- B. Study Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals shall be in digital form:
 - 1. Arc-flash study input data, including completed computer program input data sheets.
 - 2. Arc-flash study report; signed, dated, and sealed by Power Systems Analysis Specialist.
 - 3. Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data:
 - 1. For Power Systems Analysis Software Developer.
 - 2. For Power System Analysis Specialist.
 - 3. For Field Adjusting Agency.
- B. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data:
 - 1. Provide maintenance procedures in equipment manuals according to requirements in NFPA 70E.
 - 2. Operation and Maintenance Procedures: In addition to items specified in Section 017823 "Operation and Maintenance Data," provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

1.7 QUALITY ASSURANCE

- A. Study shall be performed using commercially developed and distributed software designed specifically for power system analysis.
- B. Software algorithms shall comply with requirements of standards and guides specified in this Section.
- C. Manual calculations are unacceptable.
- D. Power System Analysis Software Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
 - 1. Computer program shall be designed to perform arc-flash analysis or have a function, component, or add-on module designed to perform arc-flash analysis.
 - 2. Computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
- E. Power Systems Analysis Specialist Qualifications: Professional engineer in charge of performing the arc-flash study, analyzing the arc flash, and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
- F. Arc-Flash Study Certification: Arc-Flash Study Report shall be signed and sealed by Power Systems Analysis Specialist.
- G. Field Adjusting Agency Qualifications:
 - 1. Employer of a NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification responsible for all field adjusting of the Work.
 - 2. A member company of NETA.
 - 3. Acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. CGI CYME.
 2. EDSA Micro Corporation.
 3. ESA Inc.
 4. Operation Technology, Inc.
 5. Power Analytics, Corporation.
 6. SKM Systems Analysis, Inc.
- B. Comply with IEEE 1584 and NFPA 70E.
- C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

2.2 ARC-FLASH STUDY REPORT CONTENT

- A. Executive summary of study findings.
- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
- C. One-line diagram, showing the following:
1. Protective device designations and ampere ratings.
 2. Conductor types, sizes, and lengths.
 3. Transformer kilovolt ampere (kVA) and voltage ratings, including derating factors and environmental conditions.
 4. Motor and generator designations and kVA ratings.
 5. Switchgear, switchboard, motor-control center, panelboard designations, and ratings.
- D. Study Input Data: As described in "Power System Data" Article.
- E. Short-Circuit Study Output Data: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260573.13 "Short-Circuit Studies."
- F. Protective Device Coordination Study Report Contents: As specified in "Coordination Study Report Contents" Article in Section 260573.16 "Coordination Studies."
- G. Arc-Flash Study Output Reports:
1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each equipment location included in the report:

- a. Voltage.
- b. Calculated symmetrical fault-current magnitude and angle.
- c. Fault-point X/R ratio.
- d. No AC Decrement (NACD) ratio.
- e. Equivalent impedance.
- f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
- g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

H. Incident Energy and Flash Protection Boundary Calculations:

1. Arcing fault magnitude.
 2. Protective device clearing time.
 3. Duration of arc.
 4. Arc-flash boundary.
 5. Restricted approach boundary.
 6. Limited approach boundary.
 7. Working distance.
 8. Incident energy.
 9. Hazard risk category.
 10. Recommendations for arc-flash energy reduction.
- I. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of computer printout.

2.3 ARC-FLASH WARNING LABELS

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce a 3.5-by-5-inch self-adhesive equipment label for each work location included in the analysis.
- B. Label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:
1. Location designation.
 2. Nominal voltage.
 3. Protection boundaries.
 - a. Arc-flash boundary.
 - b. Restricted approach boundary.
 - c. Limited approach boundary.
 4. Arc flash PPE category.
 5. Required minimum arc rating of PPE in Cal/cm squared.
 6. Available incident energy.
 7. Working distance.
 8. Engineering report number, revision number, and issue date.

- C. Labels shall be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.2 ARC-FLASH HAZARD ANALYSIS

- A. Comply with NFPA 70E and its Annex D for hazard analysis study.
- B. Preparatory Studies: Perform the Short-Circuit and Protective Device Coordination studies prior to starting the Arc-Flash Hazard Analysis.
 - 1. Short-Circuit Study Output: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260573.13 "Short-Circuit Studies."
 - 2. Coordination Study Report Contents: As specified in "Coordination Study Report Contents" Article in Section 260573.16 "Coordination Studies."
- C. Calculate maximum and minimum contributions of fault-current size.
 - 1. Maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.
 - 2. Calculate arc-flash energy at 85 percent of maximum short-circuit current according to IEEE 1584 recommendations.
 - 3. Calculate arc-flash energy at 38 percent of maximum short-circuit current according to NFPA 70E recommendations.
 - 4. Calculate arc-flash energy with the utility contribution at a minimum and assume no motor contribution.
- D. Calculate the arc-flash protection boundary and incident energy at locations in electrical distribution system where personnel could perform work on energized parts.
- E. Include medium- and low-voltage equipment locations, except equipment rated 240 V ac or less fed from transformers less than 125 kVA.
- F. Calculate the limited, restricted, and prohibited approach boundaries for each location.

- G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:
 - 1. Fault contribution from induction motors shall not be considered beyond three to five cycles.
 - 2. Fault contribution from synchronous motors and generators shall be decayed to match the actual decrement of each as closely as possible (for example, contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).
- H. Arc-flash energy shall generally be reported for the maximum of line or load side of a circuit breaker. However, arc-flash computation shall be performed and reported for both line and load side of a circuit breaker as follows:
 - 1. When the circuit breaker is in a separate enclosure.
 - 2. When the line terminals of the circuit breaker are separate from the work location.
- I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.3 POWER SYSTEM DATA

- A. Obtain all data necessary for conduct of the arc-flash hazard analysis.
 - 1. Verify completeness of data supplied on one-line diagram on Drawings and under "Preparatory Studies" Paragraph in "Arc-Flash Hazard Analysis" Article. Call discrepancies to Architect's attention.
 - 2. For new equipment, use characteristics from approved submittals under provisions of action submittals and information submittals for this Project.
 - 3. For existing equipment, whether or not relocated, obtain required electrical distribution system data by field investigation and surveys conducted by qualified technicians and engineers.
- B. Electrical Survey Data: Gather and tabulate the following input data to support study. Comply with recommendations in IEEE 1584 and NFPA 70E as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification. Data include, but are not limited to, the following:
 - 1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams,

- overcurrent protective device submittals, input and output data, and recommended device settings.
2. Obtain electrical power utility impedance or available short circuit current at the service.
 3. Power sources and ties.
 4. Short-circuit current at each system bus (three phase and line to ground).
 5. Full-load current of all loads.
 6. Voltage level at each bus.
 7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
 8. For reactors, provide manufacturer and model designation, voltage rating and impedance.
 9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
 10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
 11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
 12. Busway manufacturer and model designation, current rating, impedance, lengths, size, and conductor material.
 13. Motor horsepower and NEMA MG 1 code letter designation.
 14. Low-voltage conductor sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
 15. Medium-voltage conductor sizes, lengths, conductor material, conductor construction and metallic shield performance parameters, and conduit material (magnetic or nonmagnetic).

3.4 LABELING

- A. Apply one arc-flash label on the front cover of each section of the equipment for each equipment included in the study. Base arc-flash label data on highest values calculated at each location.
- B. Each piece of equipment listed below shall have an arc-flash label applied to it:
 1. Low-voltage switchboard.
 2. Applicable panelboard and safety switch under 250 V.
- C. Note on record Drawings the location of equipment where the personnel could be exposed to arc-flash hazard during their work.
 1. Indicate arc-flash energy.
 2. Indicate protection level required.

3.5 APPLICATION OF WARNING LABELS

- A. Install arc-flash warning labels under the direct supervision and control of Power System Analysis Specialist.

3.6 DEMONSTRATION

- A. Engage Power Systems Analysis Specialist to train Owner's maintenance personnel in potential arc-flash hazards associated with working on energized equipment and the significance of arc-flash warning labels.

END OF SECTION

SECTION 260923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Time switches.
 - 2. Photoelectric switches.
 - 3. Standalone daylight-harvesting switching and dimming controls.
 - 4. Indoor occupancy and vacancy sensors.
 - 5. Switchbox-mounted occupancy sensors.
 - 6. Lighting contactors.
 - 7. Emergency shunt relays.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
 - 1. Show installation details for the following:
 - a. Occupancy sensors.
 - b. Vacancy sensors.
 - 2. Interconnection diagrams showing field-installed wiring.
 - 3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plan(s) and elevations, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Suspended ceiling components.
 - 2. Structural members to which equipment will be attached.

- 3. Items penetrating finished ceiling, including the following:
 - a. Luminaires.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. Control modules.
- B. Field quality-control reports.
- C. Sample Warranty: For manufacturer's warranties.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of lighting control device to include in operation and maintenance manuals.
- B. Software and Firmware Operational Documentation:
 - 1. Software operating and upgrade manuals.
 - 2. Program Software Backup: Provide names, versions, and website addresses for locations of installed software.
 - 3. Device address list.
 - 4. Printout of software application and graphic screens.

1.6 WARRANTY

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Faulty operation of lighting control software.
 - b. Faulty operation of lighting control devices.
 - 2. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 TIME SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper Industries, Inc.
 - 2. Intermatic, Inc.

3. Invensys Controls.
 4. Leviton Manufacturing Co., Inc.
 5. NSi Industries LLC.
 6. TE Connectivity Ltd.
- B. Electronic Time Switches: Solid state, programmable, with alphanumeric display; complying with UL 917.
1. Listed and labeled as defined in NFPA 70 and marked for intended location and application.
 2. Contact Configuration: DPDT.
 3. Contact Rating: 20-A ballast load, 480-V ac.
 4. Programs: Eight on-off set points on a 24-hour schedule and an annual holiday schedule that overrides the weekly operation on holidays.
 5. Programs: 4 channels; each channel is individually programmable with 40 on-off operations per week, plus four seasonal schedules that modify the basic program and an annual holiday schedule that overrides the weekly operation on holidays.
 6. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program.
 7. Astronomic Time: All channels.
 8. Automatic daylight savings time changeover.
 9. Battery Backup: Not less than seven days reserve, to maintain schedules and time clock.

2.2 OUTDOOR PHOTOELECTRIC SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper Industries, Inc.
 2. Intermatic, Inc.
 3. Leviton Manufacturing Co., Inc.
 4. NSi Industries LLC.
 5. TE Connectivity Ltd.
- B. Description: Solid state, with SPST dry contacts rated for 1800 W LED, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A, and compatible with ballasts and LED lamps.
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range.
 3. Time Delay: Fifteen-second minimum, to prevent false operation.
 4. Surge Protection: Metal-oxide varistor.
 5. Mounting: Twist lock complies with NEMA C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.
 6. Failure Mode: Luminaire stays ON.

2.3 DAYLIGHT-HARVESTING DIMMING CONTROLS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper Industries, Inc.
 2. Hubbell Building Automation, Inc.
 3. Leviton Manufacturing Co., Inc.
 4. Lithonia Lighting; Acuity Brands Lighting, Inc.
 5. Watt Stopper.
- B. Description: Sensing daylight and electrical lighting levels, the system adjusts the indoor electrical lighting levels. As daylight increases, the lights are dimmed.
1. Lighting control set point is based on two lighting conditions:
 - a. When no daylight is present (target level).
 - b. When significant daylight is present.
 2. System programming is done with two hand-held, remote-control tools.
 - a. Initial setup tool.
 - b. Tool for occupants to adjust the target levels by increasing the set point up to 25 percent, or by minimizing the electric lighting level.
- C. Ceiling-Mounted Dimming Controls: Solid-state, light-level sensor unit, with separate power pack, to detect changes in indoor lighting levels that are perceived by the eye.
- D. Electrical Components, Devices, and Accessories:
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Sensor Output: 0- to 10-V dc to operate luminaires. Sensor is powered by controller unit.
 3. Light-Level Sensor Set-Point Adjustment Range: 20 to 60 fc.
 4. LED status lights to indicate load status.
 5. Plenum rated.
- E. Power Pack: Digital controller capable of accepting 3 RJ45 inputs with two outputs rated for 20-A incandescent or LED load at 120- and 277-V ac, for 13-A ballast load or LED at 120- and 277-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc Class 2 power source, as defined by NFPA 70.
1. With integral current monitoring
 - a. Compatible with digital addressable lighting interface.
 - 1) Plenum rated.

2.4 INDOOR OCCUPANCY AND VACANCY SENSORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Bryant Electric.
2. Cooper Industries, Inc.
3. Hubbell Building Automation, Inc.
4. Leviton Manufacturing Co., Inc.
5. Lithonia Lighting; Acuity Brands Lighting, Inc.
6. Lutron Electronics Co., Inc.
7. NSi Industries LLC.
8. Philips Lighting Controls.
9. RAB Lighting.
10. Sensor Switch, Inc.
11. Square D.
12. Watt Stopper.

B. General Requirements for Sensors:

1. Ceiling-mounted, solid-state indoor occupancy and vacancy sensors.
2. Passive infrared Dual technology.
3. Separate power pack.
4. Hardwired connection to switch.
5. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
6. Operation:
 - a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 - b. Vacancy Sensor: Unless otherwise indicated, lights are manually turned on and sensor turns lights off when the room is unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 - c. Combination Sensor: Unless otherwise indicated, sensor shall be programmed to turn lights on when coverage area is occupied and turn them off when unoccupied, or to turn off lights that have been manually turned on; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
7. Sensor Output: Sensor is powered from the power pack.
8. Power: Line voltage.
9. Power Pack: Dry contacts rated for 20-A ballast or LED load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
10. Mounting:
 - a. Sensor: Suitable for mounting in any position on a standard outlet box.
 - b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
 - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
11. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
12. Bypass Switch: Override the "on" function in case of sensor failure.

13. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; turn lights off when selected lighting level is present.
- C. Dual-Technology Type: Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.
 1. Sensitivity Adjustment: Separate for each sensing technology.
 2. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
 3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.

2.5 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Bryant Electric.
 2. Cooper Industries, Inc.
 3. Hubbell Building Automation, Inc.
 4. Leviton Manufacturing Co., Inc.
 5. Lithonia Lighting; Acuity Brands Lighting, Inc.
 6. Lutron Electronics Co., Inc.
 7. NSi Industries LLC.
 8. Philips Lighting Controls.
 9. RAB Lighting.
 10. Sensor Switch, Inc.
 11. Square D.
 12. Watt Stopper.
- B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor with manual on-off switch, suitable for mounting in a single gang switchbox using hardwired connection.
 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Occupancy Sensor Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn lights off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 3. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F.
 4. Switch Rating: Not less than 800-VA ballast or LED load at 120 V, 1200-VA ballast or LED load at 277 V, and 800-W incandescent.
- C. Wall-Switch Sensor Tag OS:

1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 900 sq. ft..
2. Sensing Technology: Dual technology - PIR and ultrasonic.
3. Switch Type: field-selectable automatic "on," or manual "on," automatic "off."
4. Capable of controlling load in three-way application.
5. Voltage: Dual voltage - 120 and 277 V.
6. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
7. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
8. Concealed, "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
9. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
10. Color: White.
11. Faceplate: Color matched to switch.

2.6 DIGITAL TIMER LIGHT SWITCH

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper Industries, Inc.
 2. Intermatic, Inc.
 3. Invensys Controls.
 4. Leviton Manufacturing Co., Inc.
 5. NSi Industries LLC.
 6. TE Connectivity Ltd.
- B. Description: Combination digital timer and conventional switch lighting control unit. Switchbox-mounted, backlit LCD display, with selectable time interval in 10 minute increments.
1. Rated 960 W at 120-V ac for tungsten lighting, 10 A at 120-V ac or 10 amps at 277-V ac for ballast or LED, and 1/4 horsepower at 120-V ac.
 2. Integral relay for connection to BAS.
 3. Voltage: Match the circuit voltage.
 4. Color: White.
 5. Faceplate: Color matched to switch.

2.7 OUTDOOR MOTION SENSORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Bryant Electric.
 2. Cooper Industries, Inc.
 3. Hubbell Building Automation, Inc.
 4. Leviton Manufacturing Co., Inc.

5. Lithonia Lighting; Acuity Brands Lighting, Inc.
6. NSi Industries LLC.
7. RAB Lighting.
8. Sensor Switch, Inc.
9. Watt Stopper.

B. Description: Solid-state outdoor motion sensors.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Dual-technology (PIR and ultrasonic) type, weatherproof. Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in.. Comply with UL 773A.
3. Switch Rating:
 - a. Luminaire-Mounted Sensor: 1000-W incandescent, 500-VA fluorescent/LED.
 - b. Separately Mounted Sensor: Dry contacts rated for 20-A ballast or LED-load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
4. Switch Type: SP, field-selectable automatic "on," or manual "on," automatic "off."
5. Voltage: Match the circuit voltage type.
6. Detector Coverage:
 - a. Standard Range: 210-degree field of view, with a minimum coverage area of 900 sq. ft..
 - b. Long Range: 180-degree field of view and 110-foot detection range.
7. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
8. Concealed, "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
9. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and help eliminate false "off" switching.
10. Operating Ambient Conditions: Suitable for operation in ambient temperatures ranging from minus 40 to plus 130 deg F, rated as "raintight" according to UL 773A.

2.8 LIGHTING CONTACTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Allen-Bradley/Rockwell Automation.
 2. ASCO Power Technologies, LP; a business of Emerson Network Power.
 3. Eaton.
 4. General Electric Company.
 5. Square D.
- B. Description: Electrically operated and mechanically held, combination-type lighting contactors with nonfused disconnect, complying with NEMA ICS 2 and UL 508.

1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less THD of normal load current).
2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
3. Enclosure: Comply with NEMA 250.
4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.

2.9 EMERGENCY SHUNT RELAY

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Lighting Control and Design.
 2. Watt Stopper.
- B. Description: NC, electrically held relay, arranged for wiring in parallel with manual or automatic switching contacts; complying with UL 924.
 1. Coil Rating: 120 V.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.
- B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SENSOR INSTALLATION

- A. Comply with NECA 1.
- B. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

- C. Install and aim sensors in locations to achieve not less than 90-percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.
- D. Horizontally separate boxes mounted in opposite sides of walls so they are not in the same vertical channel. Where back-to-back box installations cannot be avoided in same framing cavity, provide junction boxes, in lieu of open cable pulls, and use "putty pads" to seal all boxes located in the same cavity to wall and cover cutouts.

3.3 CONTACTOR INSTALLATION

- A. Comply with NECA 1.
- B. Mount electrically held lighting contactors with elastomeric isolator pads to eliminate structure-borne vibration unless contactors are installed in an enclosure with factory-installed vibration isolators.
- C. Horizontally separate boxes mounted in opposite sides of walls so they are not in the same vertical channel. Where back-to-back box installations cannot be avoided in same framing cavity, provide junction boxes, in lieu of open cable pulls, and use "putty pads" to seal all boxes located in the same cavity to wall and cover cutouts.

3.4 WIRING INSTALLATION

- A. Comply with NECA 1.
- B. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch.
- C. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
- D. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.
- E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
- F. Horizontally separate boxes mounted in opposite sides of walls so they are not in the same vertical channel. Where back-to-back box installations cannot be avoided in

same framing cavity, provide junction boxes, in lieu of open cable pulls, and use "putty pads" to seal all boxes located in the same cavity to wall and cover cutouts.

3.5 IDENTIFICATION

- A. Identify components and power and control wiring according to Section 260553 "Identification for Electrical Systems."
 - 1. Identify controlled circuits in lighting contactors.
 - 2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.
- B. Label time switches and contactors with a unique designation.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate lighting control devices and perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections:
 - 1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Lighting control devices will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.7 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

3.8 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.
- B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
 1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.9 DEMONSTRATION

- A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control systems specified in Section 260943.16 "Addressable-Luminaire Lighting Controls" and Section 260943.23 "Relay-Based Lighting Controls."
- B. Train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION

SECTION 262213 - LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes distribution, dry-type transformers with a nominal primary and secondary rating of 600 V and less, with capacities up to 1500 kVA.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type and size of transformer.
 - 2. Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer.
 - 3. Sound power level (Lw) and sound pressure level (Lp) for specific distance(s). NEMA a-weighted level is minimally acceptable. Octave band spectrum levels, 63 Hz – 8k Hz, are preferred. (See 2.3.N for maximum permissible levels)
- B. Shop Drawings:
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
 - 3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.

B. Source quality-control reports.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Inspection: On receipt, inspect for and note any shipping damage to packaging and transformer.

1. If manufacturer packaging is removed for inspection, and transformer will be stored after inspection, re-package transformer using original or new packaging materials that provide protection equivalent to manufacturer's packaging.

B. Storage: Store in a warm, dry, and temperature-stable location in original shipping packaging.

C. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

D. Handling: Follow manufacturer's instructions for lifting and transporting transformers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton.
 - 2. General Electric Company.
 - 3. Siemens Industry, Inc., Energy Management Division.
 - 4. Square D; by Schneider Electric.
- B. Source Limitations: Obtain each transformer type from single source from single manufacturer.

2.2 GENERAL TRANSFORMER REQUIREMENTS

- A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.
- B. Comply with NFPA 70.
 - 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- C. Transformers Rated 15 kVA and Larger:
 - 1. Comply with 10 CFR 431 (DOE 2016) efficiency levels.
 - 2. Marked as compliant with DOE 2016 efficiency levels by an NRTL.
- D. Shipping Restraints: Paint or otherwise color-code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside the transformer enclosure.

2.3 DISTRIBUTION TRANSFORMERS

- A. Comply with NFPA 70, and list and label as complying with UL 1561.
- B. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.
 - 1. One leg per phase.

2. Core volume shall allow efficient transformer operation at 10 percent above the nominal tap voltage.
 3. Grounded to enclosure.
- C. Coils: Continuous windings without splices except for taps.
1. Coil Material: Aluminum.
 2. Internal Coil Connections: Brazed or pressure type.
 3. Terminal Connections: Bolted.
- D. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.
- E. Enclosure: Ventilated.
1. NEMA 250, Type 2: Core and coil shall be encapsulated within resin compound to seal out moisture and air.
 2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.
 3. Wiring Compartment: Sized for conduit entry and wiring installation.
 4. Finish: Comply with NEMA 250.
 - a. Finish Color: Gray weather-resistant enamel.
- F. Taps for Transformers 3 kVA and Smaller: One 5 percent tap above normal full capacity.
- G. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.
- H. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.
- I. Insulation Class, Smaller Than 30 kVA: 180 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.
- J. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 150 deg C rise above 40 deg C ambient temperature.
- K. Grounding: Provide ground-bar kit or a ground bar installed on the inside of the transformer enclosure.
- L. Wall Brackets: Manufacturer's standard brackets.

- M. Low-Sound-Level Requirements: Maximum sound levels when factory tested according to IEEE C57.12.91, as follows:

1. 9.00 kVA and Less: 40 dBA.
2. 9.01 to 30.00 kVA: 45 dBA.
3. 30.01 to 50.00 kVA: 45 dBA for K-factors of 1, 4, and 9.
4. 50.01 to 150.00 kVA: 50 dBA for K-factors of 1, 4, and 9.
5. 150.01 to 300.00 kVA: 55 dBA for K-factors of 1, 4, and 9.
6. 300.01 to 500.00 kVA: 60 dBA for K-factors of 1, 4, and 9.
7. 500.01 to 700.00: 62 dBA for K-factors of 1, 4, and 9.
8. 700.01 to 1000.00: 64 dBA for K-factors of 1, 4, and 9.

2.4 IDENTIFICATION

- A. Nameplates: Engraved, laminated-acrylic or melamine plastic signs for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

- A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.
1. Resistance measurements of all windings at rated voltage connections and at all tap connections.
 2. Ratio tests at rated voltage connections and at all tap connections.
 3. Phase relation and polarity tests at rated voltage connections.
 4. No load losses, and excitation current and rated voltage at rated voltage connections.
 5. Impedance and load losses at rated current and rated frequency at rated voltage connections.
 6. Applied and induced tensile tests.
 7. Regulation and efficiency at rated load and voltage.
 8. Insulation-Resistance Tests:
 - a. High-voltage to ground.
 - b. Low-voltage to ground.
 - c. High-voltage to low-voltage.
 9. Temperature tests.
- B. Factory Sound-Level Tests: Conduct prototype sound-level tests on production-line products.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.
- B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.
- C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.
- D. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.
- E. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.
- F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install wall-mounted transformers level and plumb with wall brackets fabricated by transformer manufacturer.
 - 1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.
- B. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.
- C. Construct concrete bases according to Section 033000 "Cast-in-Place Concrete" and anchor floor-mounted transformers according to manufacturer's written instructions and requirements in Section 260529 "Hangers and Supports for Electrical Systems."
 - 1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

- D. Secure transformer to concrete base according to manufacturer's written instructions.
- E. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.
- F. Remove shipping bolts, blocking, and wedges.

3.3 CONNECTIONS

- A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform tests and inspections.
- E. Small (Up to 167-kVA Single-Phase or 500-kVA Three-Phase) Dry-Type Transformer Field Tests:
 - 1. Visual and Mechanical Inspection.

- a. Inspect physical and mechanical condition.
 - b. Inspect anchorage, alignment, and grounding.
 - c. Verify that resilient mounts are free and that any shipping brackets have been removed.
 - d. Verify the unit is clean.
 - e. Perform specific inspections and mechanical tests recommended by manufacturer.
 - f. Verify that as-left tap connections are as specified.
 - g. Verify the presence of surge arresters and that their ratings are as specified.
 2. Electrical Tests:
 - a. Measure resistance at each winding, tap, and bolted connection.
 - b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: the value of the index shall not be less than 1.0.
 - c. Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.
 - d. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.
- F. Large (Larger Than 167-kVA Single Phase or 500-kVA Three Phase) Dry-Type Transformer Field Tests:
1. Visual and Mechanical Inspection:
 - a. Inspect physical and mechanical condition.
 - b. Inspect anchorage, alignment, and grounding.
 - c. Verify that resilient mounts are free and that any shipping brackets have been removed.
 - d. Verify the unit is clean.
 - e. Perform specific inspections and mechanical tests recommended by manufacturer.
 - f. Verify that as-left tap connections are as specified.
 - g. Verify the presence of surge arresters and that their ratings are as specified.
 2. Electrical Tests:
 - a. Measure resistance at each winding, tap, and bolted connection.
 - b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: the value of the index shall not be less than 1.0.
 - c. Perform power-factor or dissipation-factor tests on all windings.
 - d. Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.
 - e. Perform an excitation-current test on each phase.

- f. Perform an applied voltage test on all high- and low-voltage windings to ground. See IEEE C57.12.91, Sections 10.2 and 10.9.
 - g. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.
- G. Remove and replace units that do not pass tests or inspections and retest as specified above.
- H. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 ADJUSTING

- A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.
- B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 CLEANING

- A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Lighting and appliance branch-circuit panelboards.

1.3 DEFINITIONS

- A. ATS: Acceptance testing specification.
- B. GFCI: Ground-fault circuit interrupter.
- C. MCCB: Molded-case circuit breaker.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of panelboard.
 - 1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
 - 2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each panelboard and related equipment.
 - 1. Include dimensioned plans, elevations, sections, and details.
 - 2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
 - 3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.

4. Detail bus configuration, current, and voltage ratings.
5. Short-circuit current rating of panelboards and overcurrent protective devices.
6. Include evidence of NRTL listing for series rating of installed devices.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Panelboard Schedules: For installation in panelboards

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Keys: Two spares for each type of panelboard cabinet lock.

1.8 QUALITY ASSURANCE

- A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.
- B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.10 FIELD CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding 23 deg F to plus 104 deg F.
 - b. Altitude: Not exceeding 6600 feet.

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.

1. Panelboard Warranty Period: 18 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARDS AND LOAD CENTERS COMMON REQUIREMENTS

- A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NEMA PB 1.
- D. Comply with NFPA 70.
- E. Enclosures: Flush and Surface-mounted, dead-front cabinets.
 1. Rated for environmental conditions at installed location.
 - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
 2. Height: 84 inches maximum.

3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trims shall cover all live parts and shall have no exposed hardware.
4. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
5. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
6. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
7. Finishes:
 - a. Panels and Trim: Steel and galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
 - b. Back Boxes: Galvanized steel.
 - c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.

F. Incoming Mains:

1. Location: Convertible between top and bottom.
2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.

G. Phase, Neutral, and Ground Buses:

1. Material: Tin-plated aluminum.
 - a. Plating shall run entire length of bus.
 - b. Bus shall be fully rated the entire length.
2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
4. Full-Size Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.

H. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Terminations shall allow use of 75 deg C rated conductors without derating.
3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
4. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
5. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.
6. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.

7. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
- I. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include label or manual with size and type of allowable upstream and branch devices listed and labeled by an NRTL for series-connected short-circuit rating.
 1. Panelboards rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
 2. Panelboards rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

2.2 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Eaton.
 2. General Electric Company; GE Energy Management - Electrical Distribution.
 3. Siemens Energy.
 4. Square D; by Schneider Electric.
- B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- C. Mains: Circuit breaker or lugs only.
- D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.
- F. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Eaton.
 2. General Electric Company; GE Energy Management - Electrical Distribution.

3. Siemens Energy.
 4. Square D; by Schneider Electric.
- B. MCCB: Comply with UL 489, with series-connected rating to meet available fault currents.
1. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
 2. Arc-Fault Circuit Interrupter Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
 3. MCCB Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Breaker handle indicates tripped status.
 - c. UL listed for reverse connection without restrictive line or load ratings.
 - d. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
 - e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.
 - f. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.

2.4 IDENTIFICATION

- A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.
- B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.
- C. Circuit Directory: Computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.
1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.
- B. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.

- C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.
- D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Comply with NECA 1.
- C. Install panelboards and accessories according to NEMA PB 1.1.
- D. Equipment Mounting:
 - 1. Attach panelboard to the vertical finished or structural surface behind the panelboard.
- E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
- F. Mount top of trim 90 inches above finished floor unless otherwise indicated.
- G. Mount panelboard cabinet plumb and rigid without distortion of box.
- H. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- I. Mount surface-mounted panelboards to steel slotted supports 5/8 inch in depth. Orient steel slotted supports vertically.
- J. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.
 2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.
- K. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.
- L. Install filler plates in unused spaces.

3.3 IDENTIFICATION

- A. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.
- B. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- C. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Acceptance Testing Preparation:
1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 2. Test continuity of each circuit.
- C. Tests and Inspections:
1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers stated in NETA ATS, Paragraph 7.6 Circuit Breakers.. Certify compliance with test parameters.
 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 3. Perform the following infrared scan tests and inspections and prepare reports:

- a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
 - c. Instruments and Equipment:
 - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
- D. Panelboards will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.
- 1. Measure loads during period of normal facility operations.
 - 2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
 - 3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
 - 4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 20 percent.

END OF SECTION

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Standard-grade receptacles, 125 V, 20 A.
 - 2. USB receptacles.
 - 3. GFCI receptacles, 125 V, 20 A.
 - 4. Pendant cord-connector devices.
 - 5. Cord and plug sets.
 - 6. Toggle switches, 120/277 V, 20 A.
 - 7. Occupancy sensors.
 - 8. Wall-box dimmers.
 - 9. Wall plates.
 - 10. Floor service fittings.

1.3 DEFINITIONS

- A. AFCI: Arc-fault circuit interrupter.
- B. BAS: Building automation system.
- C. EMI: Electromagnetic interference.
- D. GFCI: Ground-fault circuit interrupter.
- E. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- F. RFI: Radio-frequency interference.

- G. SPD: Surge protective device.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.1 GENERAL WIRING-DEVICE REQUIREMENTS

- A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Eaton (Arrow Hart).
 - b. Hubbell Incorporated; Wiring Device-Kellems.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour/Legrand.
 - e. Wattstopper.
- B. Comply with NFPA 70.
- C. RoHS compliant.
- D. Comply with NEMA WD 1.

E. Devices for Owner-Furnished Equipment:

1. Receptacles: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

F. Device Color:

1. Wiring Devices Connected to Normal Power System: White unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Essential Electrical System: Red.
3. SPD Devices: Blue.

G. Wall Plate Color: For plastic covers, match device color.

H. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 STANDARD-GRADE RECEPTACLES, 125 V, 20 A

A. Duplex Receptacles, 125 V, 20 A:

1. Description: Two pole, three wire, and self-grounding.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Standards: Comply with UL 498 and FS W-C-596.

B. Weather-Resistant Duplex Receptacle, 125 V, 20 A:

1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Standards: Comply with UL 498.
4. Marking: Listed and labeled as complying with NFPA 70, "Receptacles in Damp or Wet Locations" Article.

2.3 GFCI RECEPTACLES, 125 V, 20 A

A. Duplex GFCI Receptacles, 125 V, 20 A:

1. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Type: Feed through.
4. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.

2.4 TWIST-LOCKING RECEPTACLES

- A. Twist-Lock, Single Receptacles, 120 V, 20 A:
 - 1. Configuration: NEMA WD 6, Configuration L5-20R.
 - 2. Standards: Comply with UL 498.
- B. Twist-Lock, Single Receptacles, 250 V, 20 A:
 - 1. Configuration: NEMA WD 6, Configuration L6-20R.
 - 2. Standards: Comply with UL 498.

2.5 PENDANT CORD-CONNECTOR DEVICES

- A. Description: Matching, locking-type plug and receptacle body connector, heavy-duty grade.
- B. Configuration: NEMA WD 6, Configurations L5-20P and L5-20R.
- C. Body: Nylon, with screw-open, cable-gripping jaws and provision for attaching external cable grip.
- D. External Cable Grip: Woven wire-mesh type made of high-strength, galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.
- E. Standards: Comply with FS W-C-596.

2.6 CORD AND PLUG SETS

- A. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
- B. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.
- C. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.7 TOGGLE SWITCHES, 120/277 V, 20 A

1. Standards: Comply with UL 20 and FS W-S-896.
- B. Two-Pole Switches, 120/277 V, 20 A:
 1. Comply with UL 20 and FS W-S-896.
- C. Three-Way Switches, 120/277 V, 20 A:
 1. Comply with UL 20 and FS W-S-896.
- D. Four-Way Switches, 120/277 V, 20 A:
 1. Standards: Comply with UL 20 and FS W-S-896.
- E. Pilot-Light, Single-Pole Switches: 120/277 V, 20 A:
 1. Description: Illuminated when switch is off.
 2. Standards: Comply with UL 20 and FS W-S-896.
- F. Key-Operated, Single-Pole Switches, 120/277 V, 20 A:
 1. Description: Factory-supplied key in lieu of switch handle.
 2. Standards: Comply with UL 20 and FS W-S-896.
- G. Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches, 120/277 V, 20 A:
 1. Description: For use with mechanically held lighting contactors.
 2. Standards: Comply with NEMA WD 1, UL 20, and FS W-S-896.

2.8 WALL PLATES

- A. Single Source: Obtain wall plates from same manufacturer of wiring devices.
- B. Single and combination types shall match corresponding wiring devices.
 1. Plate-Securing Screws: Metal with head color to match plate finish.
 2. Material for Finished Spaces: Smooth, high-impact thermoplastic.
 3. Material for Unfinished Spaces: Galvanized steel.
 4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.
- C. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.
- D. Antimicrobial Cover Plates:

1. Contact surfaces treated with a coating that kills 99.9 percent of certain common bacteria within two hours when regularly and properly cleaned.
2. Tarnish resistant.

2.9 FLOOR SERVICE FITTINGS

A. Flush-Type Floor Service Fittings:

1. Description: Type: Modular, flush-type, dual-service units suitable for wiring method used, with cover flush with finished floor.
2. Compartments: Barrier separates power from voice and data communication cabling.
3. Service Plate and Cover: Rectangular, solid brass with satin finish.
4. Power Receptacle: NEMA WD 6 Configuration 5-20R, gray finish, unless otherwise indicated.
5. Data Communication Outlet: Blank cover with bushed cable opening.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.
- B. Coordination with Other Trades:
 1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes, and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
 2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
 3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
 4. Install wiring devices after all wall preparation, including painting, is complete.
- C. Conductors:
 1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
 2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
 3. The length of free conductors at outlets for devices shall comply with NFPA 70, Article 300, without pigtails.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.
10. Horizontally separate boxes mounted in opposite sides of walls so they are not in the same vertical channel. Where back-to-back box installations cannot be avoided in same framing cavity, provide junction boxes, in lieu of open cable pulls, and use "putty pads" to seal all boxes located in the same cavity to wall and cover cutouts.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.
2. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:

1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan-speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device, listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

- I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 GFCI RECEPTACLES

- A. Do not use the feed through feature of GFCI Receptacles. Each receptacle indicated on plans as a GFCI receptacle will be a GFCI type receptacle.

3.3 IDENTIFICATION

- A. Comply with Section 260553 "Identification for Electrical Systems."
- B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.
- C. Essential Electrical System: Mark receptacles supplied from the essential electrical system to allow easy identification using a self-adhesive label.

3.4 FIELD QUALITY CONTROL

- A. Test Instruments: Use instruments that comply with UL 1436.
- B. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.
- C. Tests for Receptacles:
 1. Line Voltage: Acceptable range is 105 to 132 V.
 2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
 3. Ground Impedance: Values of up to 2 ohms are acceptable.
 4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
 5. Using the test plug, verify that the device and its outlet box are securely mounted.
 6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault-current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

- D. Test straight-blade for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz..
- E. Wiring device will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

END OF SECTION

SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Fusible switches.
 - 2. Nonfusible switches.
 - 3. Molded-case circuit breakers (MCCBs).
 - 4. Enclosures.

1.3 DEFINITIONS

- A. NC: Normally closed.
- B. NO: Normally open.
- C. SPDT: Single pole, double throw.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
 - 1. Enclosure types and details for types other than NEMA 250, Type 1.
 - 2. Current and voltage ratings.
 - 3. Short-circuit current ratings (interrupting and withstand, as appropriate).
 - 4. Include evidence of a nationally recognized testing laboratory (NRTL) listing for series rating of installed devices.

5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
 6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF electronic format.
- B. Shop Drawings: For enclosed switches and circuit breakers.
1. Include plans, elevations, sections, details, and attachments to other work.
 2. Include wiring diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified testing agency.
- B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.
1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Accredited by NETA.
1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.8 FIELD CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
 2. Altitude: Not exceeding 6600 feet.

1.9 WARRANTY

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- D. Comply with NFPA 70.
- E. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. ABB Inc.
 - 2. Eaton.
 - 3. General Electric Company.
 - 4. Siemens Industry, Inc.
 - 5. Square D; by Schneider Electric.

2.2 FUSIBLE SWITCHES

- A. Type HD, Heavy Duty:
 - 1. Single throw.
 - 2. Three pole.
 - 3. 240-V ac.
 - 4. 1200 A and smaller.

5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses.
6. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

B. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Lugs: Mechanical type, suitable for number, size, and conductor material.
5. Service-Rated Switches: Labeled for use as service equipment.

2.3 NONFUSIBLE SWITCHES

- A. Type GD, General Duty, Three Pole, Single Throw, 240-V ac, 600 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.
- B. Type HD, Heavy Duty, Three Pole, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- C. Accessories:
 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 3. Lugs: Mechanical type, suitable for number, size, and conductor material.
 4. Service-Rated Switches: Labeled for use as service equipment.

2.4 MOLDED-CASE CIRCUIT BREAKERS

- A. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.
- B. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit

breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.

- C. MCCBs shall be equipped with a device for locking in the isolated position.
- D. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.
- E. Features and Accessories:
 - 1. Standard frame sizes, trip ratings, and number of poles.
 - 2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.

2.5 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
- B. Enclosure Finish: The enclosure shall be gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (NEMA 250 Type 1).
- C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA 250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.
- D. Operating Mechanism: The circuit-breaker operating handle shall be externally operable with the operating mechanism being an integral part of the box, not the cover. The cover interlock mechanism shall have an externally operated override. The override shall not permanently disable the interlock mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.
- E. Enclosures designated as NEMA 250 Type 4, 4X stainless steel, 12, or 12K shall have a dual cover interlock mechanism to prevent unintentional opening of the enclosure cover when the circuit breaker is ON and to prevent turning the circuit breaker ON when the enclosure cover is open.
- F. NEMA 250 Type 7/9 enclosures shall be furnished with a breather and drain kit to allow their use in outdoor and wet location applications.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
 - 1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.

3.2 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

- A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.
 - 1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
 - 2. Outdoor Locations: NEMA 250, Type 3R.
 - 3. Kitchen Areas: NEMA 250, Type 4X.
 - 4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
 - 5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

3.3 INSTALLATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- C. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- D. Install fuses in fusible devices.
- E. Comply with NFPA 70 and NECA 1.

3.4 IDENTIFICATION

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections for Switches and Molded Case Circuit Breakers:
 - 1. Visual and Mechanical Inspection:
 - a. Inspect physical and mechanical condition.
 - b. Inspect anchorage, alignment, grounding, and clearances.
 - c. Verify that the unit is clean.
 - d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
 - e. Verify that fuse sizes and types match the Specifications and Drawings.
 - f. Verify that each fuse has adequate mechanical support and contact integrity.
 - g. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.
 - h. Verify correct phase barrier installation.
 - i. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.
- C. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.
 - 1. Test procedures used.
 - 2. Include identification of each enclosed switch and circuit breaker tested and describe test results.
 - 3. List deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

END OF SECTION

SECTION 262913.03 – MANUAL AND MAGNETIC MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Manual motor controllers.
 - 2. Enclosed full-voltage magnetic motor controllers.
 - 3. Combination full-voltage magnetic motor controllers.
 - 4. Enclosures.
 - 5. Accessories.
 - 6. Identification.

1.3 DEFINITIONS

- A. CPT: Control power transformer.
- B. MCCB: Molded-case circuit breaker.
- C. MCP: Motor circuit protector.
- D. NC: Normally closed.
- E. OCPD: Overcurrent protective device.
- F. SCCR: Short-circuit current rating.
- G. SCPD: Short-circuit protective device.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Sound power level (Lw) or sound pressure level (Lp) for specific distance(s). A-weighted level minimally acceptable. Octave band levels, 63 Hz – 8k Hz, preferred.

B. Shop Drawings: For each type of magnetic controller.

1. Include plans, elevations, sections, and mounting details.
2. Indicate dimensions, weights, required clearances, and location and size of each field connection.
3. Include features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

C. Product Schedule: List the following for each enclosed controller:

1. Each installed magnetic controller type.
2. NRTL listing.
3. Factory-installed accessories.
4. Nameplate legends.
5. SCCR of integrated unit.
6. For each combination magnetic controller include features, characteristics, ratings, and factory setting of the SCPD and OCPD.
 - a. Listing document proving Type 2 coordination.
7. For each series-rated combination state the listed integrated short-circuit current (withstand) rating of SCPD and OCPDs by an NRTL acceptable to authorities having jurisdiction.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For magnetic controllers to include in operation and maintenance manuals.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.7 FIELD CONDITIONS

- A. Ambient Environment Ratings: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - 1. Ambient Temperature: Not less than 23 deg F and not exceeding 104 deg F.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- B. UL Compliance: Fabricate and label magnetic motor controllers to comply with UL 508 and UL 60947-4-1.
- C. NEMA Compliance: Fabricate motor controllers to comply with ICS 2.
- D. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton.
 - 2. General Electric Company.
 - 3. Rockwell Automation, Inc.
 - 4. Siemens Industry, Inc., Energy Management Division.
 - 5. Square D; by Schneider Electric.

2.2 MANUAL MOTOR CONTROLLERS

- A. Motor-Starting Switches (MSS): "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.
 - 1. Standard: Comply with NEMA ICS 2, general purpose, Class A.
 - 2. Configuration: Nonreversing.
 - 3. Surface mounting.
 - 4. Red pilot light.

2.3 ENCLOSED FULL-VOLTAGE MAGNETIC MOTOR CONTROLLERS

- A. Description: Across-the-line start, electrically held, for nominal system voltage of 600-V ac and less.

- B. Standard: Comply with NEMA ICS 2, general purpose, Class A.
- C. Configuration: Nonreversing.
- D. Contactor Coils: Pressure-encapsulated type.
 - 1. Operating Voltage: Manufacturer's standard, unless indicated.
- E. Control Power:
 - 1. For on-board control power, obtain from line circuit or from integral CPT. The CPT shall have capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - a. Spare CPT Capacity as Indicated on Drawings: 50 VA.
- F. Overload Relays:
 - 1. Thermal Overload Relays:
 - a. Inverse-time-current characteristic.
 - b. Class 10 tripping characteristic.
 - c. Heaters in each phase shall be matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - d. Ambient compensated.
 - e. Automatic resetting.

2.4 COMBINATION FULL-VOLTAGE MAGNETIC MOTOR CONTROLLER

- A. Description: Factory-assembled, combination full-voltage magnetic motor controller consisting of the controller described in this article, indicated disconnecting means, SCPD and OCPD, in a single enclosure.
- B. Standard: Comply with NEMA ICS 2, general purpose, Class A.
- C. Configuration: Nonreversing.
- D. Contactor Coils: Pressure-encapsulated type.
 - 1. Operating Voltage: Manufacturer's standard, unless indicated.
- E. Control Power:
 - 1. For on-board control power, obtain from line circuit or from integral CPT. The CPT shall have capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - a. Spare CPT Capacity as Indicated on Drawings: 50 VA.

F. Overload Relays:

1. Thermal Overload Relays:
 - a. Inverse-time-current characteristic.
 - b. Class 10 tripping characteristic.
 - c. Heaters in each phase shall be matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - d. Ambient compensated.
 - e. Automatic resetting.

G. Fusible Disconnecting Means:

1. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate indicated fuses.
2. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

H. Nonfusible Disconnecting Means:

1. NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
2. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

I. MCP Disconnecting Means:

1. UL 489 and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
2. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

J. MCCB Disconnecting Means:

1. UL 489 and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse-time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
2. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
3. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

2.5 ENCLOSURES

- A. Comply with NEMA 250, type designations as indicated on Drawings, complying with environmental conditions at installed location.
- B. The construction of the enclosures shall comply with NEMA ICS 6.

- C. Controllers in hazardous (classified) locations shall comply with UL 1203.

2.6 IDENTIFICATION

- A. Controller Nameplates: Laminated acrylic or melamine plastic signs, as described in Section 260553 "Identification for Electrical Systems," for each compartment, mounted with corrosion-resistant screws.
- B. Arc-Flash Warning Labels:
 - 1. Comply with requirements in Section 260573.19 "Arc-Flash Hazard Analysis." Produce a 3.5-by-5-inch self-adhesive equipment label for each work location included in the analysis.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and space conditions for compliance with requirements for motor controllers, their relationship with the motors, and other conditions affecting performance of the Work.

3.2 INSTALLATION

- A. Comply with NECA 1.
- B. Wall-Mounted Controllers: Install magnetic controllers on walls with tops at uniform height indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems" unless otherwise indicated.
- C. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.
- D. Setting of Overload Relays: Select and set overloads on the basis of full-load current rating as shown on motor nameplate. Adjust setting value for special motors as required by NFPA 70 for motors that are high-torque, high-efficiency, and so on.

3.3 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Comply with the provisions of NFPA 70B, "Testing and Test Methods" Chapter.
 - 2. Visual and Mechanical Inspection:
 - a. Compare equipment nameplate data with drawings and specifications.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, and grounding.
 - d. Verify the unit is clean.
 - e. Inspect contactors:
 - 1) Verify mechanical operation.
 - 2) Verify contact gap, wipe, alignment, and pressure are according to manufacturer's published data.
 - f. Motor-Running Protection:
 - 1) Verify overload element rating is correct for its application.
 - 2) If motor-running protection is provided by fuses, verify correct fuse rating.
 - g. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
- C. Motor controller will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.5 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain switchgear.

END OF SECTION

SECTION 262923 - VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes separately enclosed, preassembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

1.3 DEFINITIONS

- A. CPT: Control power transformer.
- B. DDC: Direct digital control.
- C. EMI: Electromagnetic interference.
- D. LED: Light-emitting diode.
- E. NC: Normally closed.
- F. NO: Normally open.
- G. OCPD: Overcurrent protective device.
- H. PID: Control action, proportional plus integral plus derivative.
- I. RFI: Radio-frequency interference.
- J. VFC: Variable-frequency motor controller.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type and rating of VFC indicated.
 - 1. Include dimensions and finishes for VFCs.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 3. Sound power level (Lw) or sound pressure level (Lp) for specific distance(s). A-weighted level minimally acceptable. Octave band levels, 63 Hz – 8k Hz, preferred.
- B. Shop Drawings: For each VFC indicated.
 - 1. Include mounting and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For VFCs to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and motor-circuit protector trip settings.
 - b. Manufacturer's written instructions for setting field-adjustable overload relays.
 - c. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
 - d. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
 - e. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate, full-load currents.
 - f. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside controllers and install temporary electric heating, with at least 250 W per controller.

1.8 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB Low Voltage HVAC Drives.
2. Danfoss Inc.
3. Eaton.
4. General Electric Company.
5. Rockwell Automation, Inc.
6. Schneider Electric USA, Inc.
7. Siemens Industry, Inc., Building Technologies Division.
8. Siemens Industry, Inc., Energy Management Division.
9. Yaskawa Electric America, Inc.

2.2 SYSTEM DESCRIPTION

- A. General Requirements for VFCs:

1. VFCs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508A.

- B. Application: variable torque.

- C. VFC Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.
 - 1. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
 - 2. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.
- D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.
- E. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.
- F. Unit Operating Requirements:
 - 1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFC input voltage rating.
 - 2. Input AC Voltage Unbalance: Not exceeding 5 percent.
 - 3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
 - 4. Minimum Efficiency: 96 percent at 60 Hz, full load.
 - 5. Minimum Displacement Primary-Side Power Factor: 96 percent under any load or speed condition.
 - 6. Minimum Short-Circuit Current (Withstand) Rating: 10 kA.
 - 7. Ambient Temperature Rating: Not less than 32 deg F and not exceeding 104 deg F.
 - 8. Humidity Rating: Less than 95 percent (noncondensing).
 - 9. Altitude Rating: Not exceeding 3300 feet.
 - 10. Vibration Withstand: Comply with NEMA ICS 61800-2.
 - 11. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
 - 12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
 - 13. Speed Regulation: Plus or minus 5 percent.
 - 14. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
 - 15. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.
- G. Inverter Logic: Microprocessor based, 32 bit, isolated from all power circuits.
- H. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.
 - 1. Signal: Electrical.

I. Internal Adjustability Capabilities:

1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 0.1 to 999.9 seconds.
4. Deceleration: 0.1 to 999.9 seconds.
5. Current Limit: 30 to minimum of 150 percent of maximum rating.

J. Self-Protection and Reliability Features:

1. Surge Suppression: Factory installed as an integral part of the VFC, complying with UL 1449 SPD, Type 1 or Type 2.
2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
3. Under- and overvoltage trips.
4. Inverter overcurrent trips.
5. VFC and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
6. Critical frequency rejection, with three selectable, adjustable deadbands.
7. Instantaneous line-to-line and line-to-ground overcurrent trips.
8. Loss-of-phase protection.
9. Reverse-phase protection.
10. Short-circuit protection.
11. Motor-overtemperature fault.

K. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

L. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

M. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

N. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

O. Integral Input Disconnecting Means and OCPD: UL 489, instantaneous-trip circuit breaker with pad-lockable, door-mounted handle mechanism.

1. Disconnect Rating: Not less than 115 percent of VFC input current rating.
2. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
3. Auxiliary Contacts: NO or NC, arranged to activate before switch blades open.
4. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.
5. NO alarm contact that operates only when circuit breaker has tripped.

2.3 CONTROLS AND INDICATION

A. Status Lights: Door-mounted LED indicators displaying the following conditions:

1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
 - a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.

C. Historical Logging Information and Displays:

1. Running log of total power versus time.
2. Total run time.
3. Fault log, maintaining last four faults with time and date stamp for each.

D. Indicating Devices: Digital display mounted flush in VFC door and connected to display VFC parameters including, but not limited to:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (V dc).
9. Set point frequency (Hz).

10. Motor output voltage (V ac).

E. Control Signal Interfaces:

1. Electric Input Signal Interface:
 - a. A minimum of two programmable analog inputs: 0- to 10-V dc or 4- to 20-mA dc.
 - b. A minimum of six multifunction programmable digital inputs.
2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the DDC system for HVAC or other control systems:
 - a. 0- to 10-V dc.
 - b. 4- to 20-mA dc.
 - c. Potentiometer using up/down digital inputs.
 - d. Fixed frequencies using digital inputs.
3. Output Signal Interface: A minimum of one programmable analog output signal(s) (0- to 10-V dc or 4- to 20-mA dc), which can be configured for any of the following:
 - a. Output frequency (Hz).
 - b. Output current (load).
 - c. DC-link voltage (V dc).
 - d. Motor torque (percent).
 - e. Motor speed (rpm).
 - f. Set point frequency (Hz).
4. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
 - a. Motor running.
 - b. Set point speed reached.
 - c. Fault and warning indication (overtemperature or overcurrent).
 - d. PID high- or low-speed limits reached.

F. Interface with DDC System for HVAC: Factory-installed hardware and software shall interface with DDC system for HVAC to monitor, control, display, and record data for use in processing reports. VFC settings shall be retained within VFC's nonvolatile memory.

1. Refer to drawings for monitored points.
2. Communication Interface: Comply with ASHRAE 135. Communication shall interface with DDC system for HVAC to remotely control and monitor lighting from a DDC system for HVAC operator workstation. Control features and monitoring points displayed locally at lighting panel shall be available through the DDC system for HVAC.

2.4 ENCLOSURES

A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1.
2. Outdoor Locations: Type 3R.

3. Kitchen Areas: Type 4X,.
 4. Other Wet or Damp Indoor Locations: Type 4.
 5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.
- B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFC as "Plenum Rated."

2.5 ACCESSORIES

2.6 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.
1. Test each VFC while connected to a motor that is comparable to that for which the VFC is rated.
 2. Verification of Performance: Rate VFCs according to operation of functions and features specified.
- B. VFCs will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances, insert Project-specific conditions, and other conditions affecting performance of the Work.
- B. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.
- D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work

- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."
- B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- C. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors are installed.
- D. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.
- E. Comply with NECA 1.

3.3 CONTROL WIRING INSTALLATION

- A. Install wiring between VFCs and remote devices and facility's central-control system. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."
- B. Bundle, train, and support wiring in enclosures.
- C. Connect selector switches and other automatic-control devices where applicable.
 - 1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switches are in manual-control position.
 - 2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor-overload protectors.

3.4 IDENTIFICATION

- A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each VFC with engraved nameplate.
 - 3. Label each enclosure-mounted control and pilot device.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- D. Tests and Inspections:
 - 1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
 - 2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
 - 3. Test continuity of each circuit.
 - 4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Owner before starting the motor(s).
 - 5. Test each motor for proper phase rotation.
 - 6. Perform tests according to the Inspection and Test Procedures for Adjustable Speed Drives stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 8. Perform the following infrared (thermographic) scan tests and inspections, and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each VFC. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each VFC 11 months after date of Substantial Completion.

- c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
- 9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- E. VFCs will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.6 STARTUP SERVICE

- A. Perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.

3.7 ADJUSTING

- A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

3.8 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.
- B. Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.9 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs.

END OF SECTION

SECTION 264113 - LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Provide the Design, Equipment and Installation of lightning protection systems.
- B. Section includes lightning protection system for ordinary structures.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
 - 1. Include layouts of the lightning protection system, with details of the components to be used in the installation.
 - 2. Include raceway locations needed for the installation of conductors.
 - 3. Details of air terminals, ground rods, ground rings, conductor supports, splices, and terminations, including concealment requirements.
 - 4. Include roof attachment details, coordinated with roof installation.
 - 5. Calculations required by NFPA 780 for bonding of metal bodies.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Lightning protection system Shop Drawings, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Lightning protection cabling attachments to roofing systems and accessories.
 - 2. Lightning protection strike termination device attachment to roofing systems, coordinated with the roofing system manufacturer.

3. Lightning protection system components penetrating roofing and moisture protection systems and system components, coordinated with the roofing system manufacturer.
- B. Qualification Data: For Installer.
- C. Product Certificates: For each type of roof adhesive for attaching the roof-mounted air terminal assemblies, approved by the roofing-material manufacturer.
- D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For lightning protection system to include in maintenance manuals.
 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Dimensioned site plan showing dimensioned route of the ground loop conductor and the ground rod locations. Comply with requirements of Section 017839 "Project Record Documents."
 - b. A system testing and inspection record, listing the results of inspections and ground resistance tests, as recommended by NFPA 780, Annex D.
- B. Completion Certificate:
 1. UL Master Label Certificate.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: UL-listed installer, category OWAY.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Advanced Lightning Technology, Ltd.
 2. East Coast Lightning Equipment Inc.
 3. ERICO; a brand of nVent.
 4. Harger Lightning & Grounding.
 5. Heary Bros. Lightning Protection Co. Inc.

6. Independent Protection Co.
7. National Lightning Protection.
8. Preferred Lightning Protection.
9. Robbins Lightning, Inc.
10. Thompson Lightning Protection, Inc.

2.2 PERFORMANCE REQUIREMENTS

- A. NFPA Lightning Protection Standard: Comply with NFPA 780 requirements for Class I buildings.
- B. Lightning Protection Components, Devices, and Accessories: Listed and labeled by a qualified testing agency as complying with UL 96, and marked for intended location and application.

2.3 MATERIALS

- A. Air Terminals:
 1. Aluminum unless otherwise indicated.
 2. 1/2-inch diameter by 10 inches long minimum.
 3. Rounded tip.
 4. Integral base support.
- B. Air Terminal Bracing:
 1. Aluminum.
 2. 1/4-inch diameter rod.
- C. Class 1 Main Conductors:
 1. Aluminum: 98,600 circular mils in diameter.
- D. Secondary Conductors:
 1. Aluminum: 41,400 circular mils in diameter.
- E. Ground Rods:
 1. Material: Copper-clad steel.
 2. Diameter: 5/8 inch.
 3. Rods shall be not less than 120 inches long.
- F. Conductor Splices and Connectors: Compression fittings that are installed with hydraulically operated tools, or exothermic welds, approved for use with the class type.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install lightning protection components and systems according to NFPA 780.
- B. Install conductors with direct paths from air terminals to ground connections. Avoid bends less than 90 degrees and 8 inches in radius and narrow loops.
- C. Conceal conductors within normal view from exterior locations at grade within 200 feet of building. Comply with requirements for concealed systems in NFPA 780.
 - 1. Roof penetrations required for down conductors and connections to structural-steel framework shall be made using listed through-roof fitting and connector assemblies with solid rods and appropriate roof flashings. Use materials approved by the roofing manufacturer for the purpose. Conform to the methods and materials required at roofing penetrations of the lightning protection components to ensure compatibility with the roofing specifications and warranty.
 - 2. Install conduit where necessary to comply with conductor concealment requirements.
 - 3. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.
- D. Ground Ring Electrode: The conductor shall be not less than the main-size lightning conductor.

3.2 CONNECTIONS

- A. Aboveground concealed connections, and connections in earth or concrete, shall be done by exothermic welds or by high-compression fittings listed for the purpose.
- B. Aboveground exposed connections shall be done using the following types of connectors, listed and labeled for the purpose: exothermic weld.
- C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
 - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

3.3 CORROSION PROTECTION

- A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.
- B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

3.4 FIELD QUALITY CONTROL

- A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:
 - 1. Perform inspections as required to obtain a UL Master Label for system.
 - 2. Perform inspections to obtain an LPI certification.
- B. Prepare test and inspection reports and certificates.

END OF SECTION

SECTION 265119 - LED INTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes the following types of LED luminaires:

1. Cylinder.
2. Downlight.
3. Linear industrial.
4. Recessed, linear.
5. Strip light.
6. Surface mount, linear.
7. Surface mount, nonlinear.
8. Suspended, linear.
9. Suspended, nonlinear.

1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color Rendering Index.
- C. Fixture: See "Luminaire."
- D. IP: International Protection or Ingress Protection Rating.
- E. LED: Light-emitting diode.
- F. Lumen: Measured output of lamp and luminaire, or both.
- G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Arrange in order of luminaire designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaires.
4. Include emergency lighting units, including batteries and chargers.
5. Include life, output (lumens, CCT, and CRI), and energy-efficiency data.
6. Photometric data and adjustment factors based on laboratory tests.
 - a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
 - b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.6 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under

the NVLAP for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.

- C. Provide luminaires from a single manufacturer for each luminaire type.
- D. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.8 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
- B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 LUMINAIRE REQUIREMENTS

- A. Manufacturers: Refer to Lighting Fixture Schedule on drawings for luminaire selections.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
 - 1. Label shall include the following lamp characteristics:
 - a. "USE ONLY" and include specific lamp type.
 - b. Lamp diameter, shape, size, wattage, and coating.
 - c. CCT and CRI.
- D. Nominal Operating Voltage: As indicated on plans.

- E. Minimum light output (lm), as indicated on lighting fixture schedule on drawings.
- F. Minimum allowable efficacy of 80 lm/W.
- G. CRI of minimum 80.
- H. CCT as indicated in lighting fixture schedule on drawings.
- I. Rated lamp life of 50,000 hours to L70
- J. Dimmable from 100 percent to 0 percent of maximum light output.
- K. Internal driver.
- L. Diffusers and Globes:
 - 1. Lens thickness at least 0.125-inch unless otherwise noted.
 - 2. Glass: Annealed crystal glass unless otherwise indicated
 - 3. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 - 4. Lenses shall be adjustable where indicated.
 - 5. Light distribution shall be as indicated.
- M. Housings:
 - 1. Extruded-aluminum housing and heat sink.
 - 2. Clear anodized finish.
 - 3. Integral junction box with conduit fittings.
 - 4. Universal mounting bracket.
- N. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
- O. With integral mounting provisions.
- P. Standards:
 - 1. ENERGY STAR certified.
 - 2. RoHS compliant.
 - 3. UL Listing: Listed for damp location.

4. Recessed luminaires shall comply with NEMA LE4.

2.2 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Steel:

1. ASTM A 36/A 36M for carbon structural steel.
2. ASTM A 568/A 568M for sheet steel.

C. Stainless Steel:

1. Manufacturer's standard grade.
2. Manufacturer's standard type, ASTM A 240/240 M.

D. Galvanized Steel: ASTM A 653/A 653M.

E. Aluminum: ASTM B 209.

2.3 METAL FINISHES

- A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.4 LUMINAIRE SUPPORT

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.
- C. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, 12 gage.
- D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

- E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

- A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.3 INSTALLATION

- A. Comply with NECA 1.
- B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.
- C. Install lamps in each luminaire.
- D. Supports:
 - 1. Sized and rated for luminaire weight.
 - 2. Able to maintain luminaire position after cleaning and relamping.
 - 3. Provide support for luminaire without causing deflection of ceiling or wall.
 - 4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

E. Flush-Mounted Luminaires:

1. Secured to outlet box.
2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

F. Wall-Mounted Luminaires:

1. Attached to structural members in walls or Attached to a minimum 20 gauge backing plate attached to wall structural members.
2. Do not attach luminaires directly to gypsum board.

G. Suspended Luminaires:

1. Ceiling Mount:
 - a. Pendant mount with 5/32-inch- diameter aircraft cable supports length as indicated on lighting fixture schedule..
 - b. Hook mount.
2. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
3. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
4. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and and support for suspension for each unit length of luminaire chassis, including one at each end.
5. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

H. Ceiling-Grid-Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

- I. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.4 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
 - 2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.
- B. Luminaire will be considered defective if it does not pass operation tests and inspections.
- C. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Occupancy Adjustments: Provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions.

END OF SECTION

SECTION 265619 – LED EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.
 - 2. Luminaire supports.

1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color rendering index.
- C. Fixture: See "Luminaire."
- D. IP: International Protection or Ingress Protection Rating.
- E. Lumen: Measured output of lamp and luminaire, or both.
- F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of luminaire.
 - 1. Arrange in order of luminaire designation.
 - 2. Include data on features, accessories, and finishes.

3. Include physical description and dimensions of luminaire.
4. Lamps, include life, output (lumens, CCT, and CRI), and energy-efficiency data.
5. Photometric data and adjustment factors based on laboratory tests, complying with IES Lighting Measurements Testing and Calculation Guides, of each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project.
6. Wiring diagrams for power, control, and signal wiring.
7. Means of attaching luminaires to supports and indication that the attachment is suitable for components involved.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires to include in operation and maintenance manuals.

1. Provide a list of all lamp types used on Project. Use ANSI and manufacturers' codes.
2. Provide a list of all photoelectric relay types used on Project; use manufacturers' codes.

1.6 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturers' laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Provide luminaires from a single manufacturer for each luminaire type.

C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

D. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering prior to shipping.

1.8 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within a warranty period or one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 LUMINAIRE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.
- C. UL Compliance: Comply with UL 1598 and listed for wet location.
- D. Lamp base complying with ANSI C81.61 or IEC 60061-1.
- E. Bulb shape complying with ANSI C79.1.
- F. Manufacturers: Refer to Lighting Fixture Schedule on drawings for luminaire types.
 - 1. Refer to drawings for luminaire mounting type, height, bases, poles, luminaire shapes and lighting distribution, luminaire housing and finish...
- G. CRI of 80.
- H. CCT of as indicated in the Lighting Fixture Schedule on drawings.
- I. L70 lamp life of 50,000 hours.

- J. Lamps dimmable from 100 percent to 0 percent of maximum light output.
- K. Internal driver.
- L. Nominal Operating Voltage: As indicated on plans
- M. In-line Fusing: Separate in-line fuse for each luminaire.
- N. Lamp Rating: Lamp marked for outdoor use.
- O. Source Limitations: Obtain luminaires from single source from a single manufacturer.
- P. Source Limitations: For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

2.2 FINISHES

- A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
- B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

2.3 LUMINAIRE SUPPORT COMPONENTS

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for luminaire electrical conduit to verify actual locations of conduit connections before luminaire installation.
- C. Examine walls, roofs, and canopy ceilings for suitable conditions where luminaires will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

- A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is substantially complete, clean luminaires used for temporary lighting and install new lamps.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Comply with NECA 1.
- B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
- C. Install lamps in each luminaire.
- D. Fasten luminaire to structural support.
- E. Supports:
 - 1. Sized and rated for luminaire weight.
 - 2. Able to maintain luminaire position after cleaning and relamping.
 - 3. Support luminaires without causing deflection of finished surface.

4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

F. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls or Attached to a minimum 1/8 inch backing plate attached to wall structural members.

G. Wiring Method: Install cables in raceways. Conceal raceways and cables.

H. Install luminaires level, plumb, and square with finished grade unless otherwise indicated. Install luminaires at height and aiming angle as indicated on Drawings.

I. Coordinate layout and installation of luminaires with other construction.

J. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.

K. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.4 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.6 FIELD QUALITY CONTROL

- A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.
- B. Perform the following tests and inspections:
 - 1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
 - 2. Verify operation of photoelectric controls.
- C. Illumination Tests:
 - 1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IES testing guide(s):
 - a. IES LM-5.
 - b. IES LM-50.
 - c. IES LM-52.
 - d. IES LM-64.
 - e. IES LM-72.
 - 2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
- D. Luminaire will be considered defective if it does not pass tests and inspections.
- E. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.7 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain luminaires and photocell relays.

END OF SECTION

Special Specification RMA12

Trash Enclosure

1. DESCRIPTION

Furnish and install trash enclosure and dumpster assemblies of the type specified.

2. MATERIALS

Furnish material in accordance with the plans.

3. CONSTRUCTION

Perform work in accordance with the details shown on the plans and the requirements of this Item.

Use established industry and utility safety practices when installing, relocating, or removing assemblies located near overhead or underground utilities.

Replace damaged components. Repair damaged galvanizing in accordance with Section 445.3.5., "Repairs." Repair damaged painted areas of a assembly in accordance with Item 441, "Steel Structures" or Item 445, "Galvanizing."

Stake, install, and align each assembly as shown on the plans. The Engineer may shift an assembly's location, if necessary, to secure a more desirable location or avoid conflict with utilities. Construct foundations for assemblies in accordance with Item 416, "Drilled Shaft Foundations," and the details shown on the plans.

4. MEASUREMENT

This Item will be measured by each trash enclosure installed.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Trash Enclosure" of type specified. This price is full compensation for furnishing all materials, equipment, labor, and incidentals.

END OF SECTION RMA12

H. FHWA FORM 1273

REQUIRED CONTRACT PROVISIONS FEDERAL-AID CONSTRUCTION CONTRACTS

- I. General
- II. Nondiscrimination
- III. Non-segregated Facilities
- IV. Davis-Bacon and Related Act Provisions
- V. Contract Work Hours and Safety Standards Act Provisions
- VI. Subletting or Assigning the Contract
- VII. Safety: Accident Prevention
- VIII. False Statements Concerning Highway Projects
- IX. Implementation of Clean Air Act and Federal Water Pollution Control Act
- X. Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion
- XI. Certification Regarding Use of Contract Funds for Lobbying
- XII. Use of United States-Flag Vessels:

ATTACHMENTS

A. Employment and Materials Preference for Appalachian Development Highway System or Appalachian Local Access Road Contracts (included in Appalachian contracts only)

I. GENERAL

1. Form FHWA-1273 must be physically incorporated in each construction contract funded under title 23, United States Code, as required in 23 CFR 633.102(b) (excluding emergency contracts solely intended for debris removal). The contractor (or subcontractor) must insert this form in each subcontract and further require its inclusion in all lower tier subcontracts (excluding purchase orders, rental agreements and other agreements for supplies or services). 23 CFR 633.102(e).

The applicable requirements of Form FHWA-1273 are incorporated by reference for work done under any purchase order, rental agreement or agreement for other services. The prime contractor shall be responsible for compliance by any subcontractor, lower-tier subcontractor or service provider. 23 CFR 633.102(e).

Form FHWA-1273 must be included in all Federal-aid design-build contracts, in all subcontracts and in lower tier subcontracts (excluding subcontracts for design services, purchase orders, rental agreements and other agreements for supplies or services) in accordance with 23 CFR 633.102. The design-builder shall be responsible for compliance by any subcontractor, lower-tier subcontractor or service provider.

Contracting agencies may reference Form FHWA-1273 in solicitation-for-bids or request-for-proposals documents, however, the Form FHWA-1273 must be physically incorporated (not referenced) in all contracts, subcontracts and lower-tier subcontracts (excluding purchase orders, rental agreements and other agreements for supplies or services related to a construction contract). 23 CFR 633.102(b).

2. Subject to the applicability criteria noted in the following sections, these contract provisions shall apply to all work

performed on the contract by the contractor's own organization and with the assistance of workers under the contractor's immediate superintendence and to all work performed on the contract by piecework, station work, or by subcontract. 23 CFR 633.102(d).

3. A breach of any of the stipulations contained in these Required Contract Provisions may be sufficient grounds for withholding of progress payments, withholding of final payment, termination of the contract, suspension / debarment or any other action determined to be appropriate by the contracting agency and FHWA.

4. Selection of Labor: During the performance of this contract, the contractor shall not use convict labor for any purpose within the limits of a construction project on a Federal-aid highway unless it is labor performed by convicts who are on parole, supervised release, or probation. 23 U.S.C. 114(b). The term Federal-aid highway does not include roadways functionally classified as local roads or rural minor collectors. 23 U.S.C. 101(a).

II. NONDISCRIMINATION (23 CFR 230.107(a); 23 CFR Part 230, Subpart A, Appendix A; EO 11246)

The provisions of this section related to 23 CFR Part 230, Subpart A, Appendix A are applicable to all Federal-aid construction contracts and to all related construction subcontracts of \$10,000 or more. The provisions of 23 CFR Part 230 are not applicable to material supply, engineering, or architectural service contracts.

In addition, the contractor and all subcontractors must comply with the following policies: Executive Order 11246, 41 CFR Part 60, 29 CFR Parts 1625-1627, 23 U.S.C. 140, Section 504 of the Rehabilitation Act of 1973, as amended (29 U.S.C. 794), Title VI of the Civil Rights Act of 1964, as amended (42 U.S.C. 2000d et seq.), and related regulations including 49 CFR Parts 21, 26, and 27; and 23 CFR Parts 200, 230, and 633.

The contractor and all subcontractors must comply with: the requirements of the Equal Opportunity Clause in 41 CFR 60-1.4(b) and, for all construction contracts exceeding \$10,000, the Standard Federal Equal Employment Opportunity Construction Contract Specifications in 41 CFR 60-4.3.

Note: The U.S. Department of Labor has exclusive authority to determine compliance with Executive Order 11246 and the policies of the Secretary of Labor including 41 CFR Part 60, and 29 CFR Parts 1625-1627. The contracting agency and the FHWA have the authority and the responsibility to ensure compliance with 23 U.S.C. 140, Section 504 of the Rehabilitation Act of 1973, as amended (29 U.S.C. 794), and Title VI of the Civil Rights Act of 1964, as amended (42 U.S.C. 2000d et seq.), and related regulations including 49 CFR Parts 21, 26, and 27; and 23 CFR Parts 200, 230, and 633.

The following provision is adopted from 23 CFR Part 230, Subpart A, Appendix A, with appropriate revisions to conform to the U.S. Department of Labor (US DOL) and FHWA requirements.

1. Equal Employment Opportunity: Equal Employment Opportunity (EEO) requirements not to discriminate and to take affirmative action to assure equal opportunity as set forth under laws, executive orders, rules, regulations (see 28 CFR Part 35, 29 CFR Part 1630, 29 CFR Parts 1625-1627, 41 CFR Part 60 and 49 CFR Part 27) and orders of the Secretary of Labor as modified by the provisions prescribed herein, and imposed pursuant to 23 U.S.C. 140, shall constitute the EEO and specific affirmative action standards for the contractor's project activities under this contract. The provisions of the Americans with Disabilities Act of 1990 (42 U.S.C. 12101 et seq.) set forth under 28 CFR Part 35 and 29 CFR Part 1630 are incorporated by reference in this contract. In the execution of this contract, the contractor agrees to comply with the following minimum specific requirement activities of EEO:

a. The contractor will work with the contracting agency and the Federal Government to ensure that it has made every good faith effort to provide equal opportunity with respect to all of its terms and conditions of employment and in their review of activities under the contract. 23 CFR 230.409 (g)(4) & (5).

b. The contractor will accept as its operating policy the following statement:

"It is the policy of this Company to assure that applicants are employed, and that employees are treated during employment, without regard to their race, religion, sex, sexual orientation, gender identity, color, national origin, age or disability. Such action shall include: employment, upgrading, demotion, or transfer; recruitment or recruitment advertising; layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship, pre-apprenticeship, and/or on-the-job training."

2. EEO Officer: The contractor will designate and make known to the contracting officers an EEO Officer who will have the responsibility for and must be capable of effectively administering and promoting an active EEO program and who must be assigned adequate authority and responsibility to do so.

3. Dissemination of Policy: All members of the contractor's staff who are authorized to hire, supervise, promote, and discharge employees, or who recommend such action or are substantially involved in such action, will be made fully cognizant of and will implement the contractor's EEO policy and contractual responsibilities to provide EEO in each grade and classification of employment. To ensure that the above agreement will be met, the following actions will be taken as a minimum:

a. Periodic meetings of supervisory and personnel office employees will be conducted before the start of work and then not less often than once every six months, at which time the contractor's EEO policy and its implementation will be reviewed and explained. The meetings will be conducted by the EEO Officer or other knowledgeable company official.

b. All new supervisory or personnel office employees will be given a thorough indoctrination by the EEO Officer, covering all major aspects of the contractor's EEO obligations within thirty days following their reporting for duty with the contractor.

c. All personnel who are engaged in direct recruitment for the project will be instructed by the EEO Officer in the contractor's procedures for locating and hiring minorities and women.

d. Notices and posters setting forth the contractor's EEO policy will be placed in areas readily accessible to employees, applicants for employment and potential employees.

e. The contractor's EEO policy and the procedures to implement such policy will be brought to the attention of employees by means of meetings, employee handbooks, or other appropriate means.

4. Recruitment: When advertising for employees, the contractor will include in all advertisements for employees the notation: "An Equal Opportunity Employer." All such advertisements will be placed in publications having a large circulation among minorities and women in the area from which the project work force would normally be derived.

a. The contractor will, unless precluded by a valid bargaining agreement, conduct systematic and direct recruitment through public and private employee referral sources likely to yield qualified minorities and women. To meet this requirement, the contractor will identify sources of potential minority group employees and establish with such identified sources procedures whereby minority and women applicants may be referred to the contractor for employment consideration.

b. In the event the contractor has a valid bargaining agreement providing for exclusive hiring hall referrals, the contractor is expected to observe the provisions of that agreement to the extent that the system meets the contractor's compliance with EEO contract provisions. Where implementation of such an agreement has the effect of discriminating against minorities or women, or obligates the contractor to do the same, such implementation violates Federal nondiscrimination provisions.

c. The contractor will encourage its present employees to refer minorities and women as applicants for employment. Information and procedures with regard to referring such applicants will be discussed with employees.

5. Personnel Actions: Wages, working conditions, and employee benefits shall be established and administered, and personnel actions of every type, including hiring, upgrading, promotion, transfer, demotion, layoff, and termination, shall be taken without regard to race, color, religion, sex, sexual orientation, gender identity, national origin, age or disability. The following procedures shall be followed:

a. The contractor will conduct periodic inspections of project sites to ensure that working conditions and employee facilities do not indicate discriminatory treatment of project site personnel.

b. The contractor will periodically evaluate the spread of wages paid within each classification to determine any evidence of discriminatory wage practices.

c. The contractor will periodically review selected personnel actions in depth to determine whether there is evidence of discrimination. Where evidence is found, the contractor will promptly take corrective action. If the review indicates that the discrimination may extend beyond the actions reviewed, such corrective action shall include all affected persons.

d. The contractor will promptly investigate all complaints of alleged discrimination made to the contractor in connection with its obligations under this contract, will attempt to resolve such complaints, and will take appropriate corrective action

within a reasonable time. If the investigation indicates that the discrimination may affect persons other than the complainant, such corrective action shall include such other persons. Upon completion of each investigation, the contractor will inform every complainant of all of their avenues of appeal.

6. Training and Promotion:

a. The contractor will assist in locating, qualifying, and increasing the skills of minorities and women who are applicants for employment or current employees. Such efforts should be aimed at developing full journey level status employees in the type of trade or job classification involved.

b. Consistent with the contractor's work force requirements and as permissible under Federal and State regulations, the contractor shall make full use of training programs (i.e., apprenticeship and on-the-job training programs for the geographical area of contract performance). In the event a special provision for training is provided under this contract, this subparagraph will be superseded as indicated in the special provision. The contracting agency may reserve training positions for persons who receive welfare assistance in accordance with 23 U.S.C. 140(a).

c. The contractor will advise employees and applicants for employment of available training programs and entrance requirements for each.

d. The contractor will periodically review the training and promotion potential of employees who are minorities and women and will encourage eligible employees to apply for such training and promotion.

7. Unions: If the contractor relies in whole or in part upon unions as a source of employees, the contractor will use good faith efforts to obtain the cooperation of such unions to increase opportunities for minorities and women. 23 CFR 230.409. Actions by the contractor, either directly or through a contractor's association acting as agent, will include the procedures set forth below:

a. The contractor will use good faith efforts to develop, in cooperation with the unions, joint training programs aimed toward qualifying more minorities and women for membership in the unions and increasing the skills of minorities and women so that they may qualify for higher paying employment.

b. The contractor will use good faith efforts to incorporate an EEO clause into each union agreement to the end that such union will be contractually bound to refer applicants without regard to their race, color, religion, sex, sexual orientation, gender identity, national origin, age, or disability.

c. The contractor is to obtain information as to the referral practices and policies of the labor union except that to the extent such information is within the exclusive possession of the labor union and such labor union refuses to furnish such information to the contractor, the contractor shall so certify to the contracting agency and shall set forth what efforts have been made to obtain such information.

d. In the event the union is unable to provide the contractor with a reasonable flow of referrals within the time limit set forth in the collective bargaining agreement, the contractor will, through independent recruitment efforts, fill the employment vacancies without regard to race, color, religion, sex, sexual orientation, gender identity, national origin, age, or disability; making full efforts to obtain qualified and/or qualifiable minorities and women. The failure of a union to provide

sufficient referrals (even though it is obligated to provide exclusive referrals under the terms of a collective bargaining agreement) does not relieve the contractor from the requirements of this paragraph. In the event the union referral practice prevents the contractor from meeting the obligations pursuant to Executive Order 11246, as amended, and these special provisions, such contractor shall immediately notify the contracting agency.

8. Reasonable Accommodation for Applicants /

Employees with Disabilities: The contractor must be familiar with the requirements for and comply with the Americans with Disabilities Act and all rules and regulations established thereunder. Employers must provide reasonable accommodation in all employment activities unless to do so would cause an undue hardship.

9. Selection of Subcontractors, Procurement of Materials and Leasing of Equipment:

The contractor shall not discriminate on the grounds of race, color, religion, sex, sexual orientation, gender identity, national origin, age, or disability in the selection and retention of subcontractors, including procurement of materials and leases of equipment. The contractor shall take all necessary and reasonable steps to ensure nondiscrimination in the administration of this contract.

a. The contractor shall notify all potential subcontractors, suppliers, and lessors of their EEO obligations under this contract.

b. The contractor will use good faith efforts to ensure subcontractor compliance with their EEO obligations.

10. Assurances Required:

a. The requirements of 49 CFR Part 26 and the State DOT's FHWA-approved Disadvantaged Business Enterprise (DBE) program are incorporated by reference.

b. The contractor, subrecipient or subcontractor shall not discriminate on the basis of race, color, national origin, or sex in the performance of this contract. The contractor shall carry out applicable requirements of 49 CFR part 26 in the award and administration of DOT-assisted contracts. Failure by the contractor to carry out these requirements is a material breach of this contract, which may result in the termination of this contract or such other remedy as the recipient deems appropriate, which may include, but is not limited to:

- (1) Withholding monthly progress payments;
- (2) Assessing sanctions;
- (3) Liquidated damages; and/or
- (4) Disqualifying the contractor from future bidding as non-responsible.

c. The Title VI and nondiscrimination provisions of U.S. DOT Order 1050.2A at Appendixes A and E are incorporated by reference. 49 CFR Part 21.

11. Records and Reports: The contractor shall keep such records as necessary to document compliance with the EEO requirements. Such records shall be retained for a period of three years following the date of the final payment to the contractor for all contract work and shall be available at reasonable times and places for inspection by authorized representatives of the contracting agency and the FHWA.

a. The records kept by the contractor shall document the following:

(1) The number and work hours of minority and non-minority group members and women employed in each work classification on the project;

(2) The progress and efforts being made in cooperation with unions, when applicable, to increase employment opportunities for minorities and women; and

(3) The progress and efforts being made in locating, hiring, training, qualifying, and upgrading minorities and women.

b. The contractors and subcontractors will submit an annual report to the contracting agency each July for the duration of the project indicating the number of minority, women, and non-minority group employees currently engaged in each work classification required by the contract work. This information is to be reported on [Form FHWA-1391](#). The staffing data should represent the project work force on board in all or any part of the last payroll period preceding the end of July. If on-the-job training is being required by special provision, the contractor will be required to collect and report training data. The employment data should reflect the work force on board during all or any part of the last payroll period preceding the end of July.

III. NONSEGREGATED FACILITIES

This provision is applicable to all Federal-aid construction contracts and to all related construction subcontracts of more than \$10,000. 41 CFR 60-1.5.

As prescribed by 41 CFR 60-1.8, the contractor must ensure that facilities provided for employees are provided in such a manner that segregation on the basis of race, color, religion, sex, sexual orientation, gender identity, or national origin cannot result. The contractor may neither require such segregated use by written or oral policies nor tolerate such use by employee custom. The contractor's obligation extends further to ensure that its employees are not assigned to perform their services at any location under the contractor's control where the facilities are segregated. The term "facilities" includes waiting rooms, work areas, restaurants and other eating areas, time clocks, restrooms, washrooms, locker rooms and other storage or dressing areas, parking lots, drinking fountains, recreation or entertainment areas, transportation, and housing provided for employees. The contractor shall provide separate or single-user restrooms and necessary dressing or sleeping areas to assure privacy between sexes.

IV. DAVIS-BACON AND RELATED ACT PROVISIONS

This section is applicable to all Federal-aid construction projects exceeding \$2,000 and to all related subcontracts and lower-tier subcontracts (regardless of subcontract size), in accordance with 29 CFR 5.5. The requirements apply to all projects located within the right-of-way of a roadway that is functionally classified as Federal-aid highway. 23 U.S.C. 113. This excludes roadways functionally classified as local roads or rural minor collectors, which are exempt. 23 U.S.C. 101. Where applicable law requires that projects be treated as a project on a Federal-aid highway, the provisions of this subpart will apply regardless of the location of the project. Examples include: Surface Transportation Block Grant Program projects funded under 23 U.S.C. 133 [excluding recreational trails projects], the Nationally Significant Freight and Highway

Projects funded under 23 U.S.C. 117, and National Highway Freight Program projects funded under 23 U.S.C. 167.

The following provisions are from the U.S. Department of Labor regulations in 29 CFR 5.5 "Contract provisions and related matters" with minor revisions to conform to the FHWA-1273 format and FHWA program requirements.

1. Minimum wages (29 CFR 5.5)

a. *Wage rates and fringe benefits.* All laborers and mechanics employed or working upon the site of the work (or otherwise working in construction or development of the project under a development statute), will be paid unconditionally and not less often than once a week, and without subsequent deduction or rebate on any account (except such payroll deductions as are permitted by regulations issued by the Secretary of Labor under the Copeland Act ([29 CFR part 3](#))), the full amount of basic hourly wages and bona fide fringe benefits (or cash equivalents thereof) due at time of payment computed at rates not less than those contained in the wage determination of the Secretary of Labor which is attached hereto and made a part hereof, regardless of any contractual relationship which may be alleged to exist between the contractor and such laborers and mechanics. As provided in paragraphs (d) and (e) of 29 CFR 5.5, the appropriate wage determinations are effective by operation of law even if they have not been attached to the contract. Contributions made or costs reasonably anticipated for bona fide fringe benefits under the Davis-Bacon Act ([40 U.S.C. 3141\(2\)\(B\)](#)) on behalf of laborers or mechanics are considered wages paid to such laborers or mechanics, subject to the provisions of paragraph 1.e. of this section; also, regular contributions made or costs incurred for more than a weekly period (but not less often than quarterly) under plans, funds, or programs which cover the particular weekly period, are deemed to be constructively made or incurred during such weekly period. Such laborers and mechanics must be paid the appropriate wage rate and fringe benefits on the wage determination for the classification(s) of work actually performed, without regard to skill, except as provided in paragraph 4. of this section. Laborers or mechanics performing work in more than one classification may be compensated at the rate specified for each classification for the time actually worked therein: *Provided*, That the employer's payroll records accurately set forth the time spent in each classification in which work is performed. The wage determination (including any additional classifications and wage rates conformed under paragraph 1.c. of this section) and the Davis-Bacon poster (WH-1321) must be posted at all times by the contractor and its subcontractors at the site of the work in a prominent and accessible place where it can be easily seen by the workers.

b. *Frequently recurring classifications.* (1) In addition to wage and fringe benefit rates that have been determined to be prevailing under the procedures set forth in [29 CFR part 1](#), a wage determination may contain, pursuant to § 1.3(f), wage and fringe benefit rates for classifications of laborers and mechanics for which conformance requests are regularly submitted pursuant to paragraph 1.c. of this section, provided that:

(i) The work performed by the classification is not performed by a classification in the wage determination for which a prevailing wage rate has been determined;

(ii) The classification is used in the area by the construction industry; and

(iii) The wage rate for the classification bears a reasonable relationship to the prevailing wage rates contained in the wage determination.

(2) The Administrator will establish wage rates for such classifications in accordance with paragraph 1.c.(1)(iii) of this section. Work performed in such a classification must be paid at no less than the wage and fringe benefit rate listed on the wage determination for such classification.

c. *Conformance.* (1) The contracting officer must require that any class of laborers or mechanics, including helpers, which is not listed in the wage determination and which is to be employed under the contract be classified in conformance with the wage determination. Conformance of an additional classification and wage rate and fringe benefits is appropriate only when the following criteria have been met:

(i) The work to be performed by the classification requested is not performed by a classification in the wage determination; and

(ii) The classification is used in the area by the construction industry; and

(iii) The proposed wage rate, including any bona fide fringe benefits, bears a reasonable relationship to the wage rates contained in the wage determination.

(2) The conformance process may not be used to split, subdivide, or otherwise avoid application of classifications listed in the wage determination.

(3) If the contractor and the laborers and mechanics to be employed in the classification (if known), or their representatives, and the contracting officer agree on the classification and wage rate (including the amount designated for fringe benefits where appropriate), a report of the action taken will be sent by the contracting officer by email to DBAconformance@dol.gov. The Administrator, or an authorized representative, will approve, modify, or disapprove every additional classification action within 30 days of receipt and so advise the contracting officer or will notify the contracting officer within the 30-day period that additional time is necessary.

(4) In the event the contractor, the laborers or mechanics to be employed in the classification or their representatives, and the contracting officer do not agree on the proposed classification and wage rate (including the amount designated for fringe benefits, where appropriate), the contracting officer will, by email to DBAconformance@dol.gov, refer the questions, including the views of all interested parties and the recommendation of the contracting officer, to the Administrator for determination. The Administrator, or an authorized representative, will issue a determination within 30 days of receipt and so advise the contracting officer or will notify the contracting officer within the 30-day period that additional time is necessary.

(5) The contracting officer must promptly notify the contractor of the action taken by the Wage and Hour Division

under paragraphs 1.c.(3) and (4) of this section. The contractor must furnish a written copy of such determination to each affected worker or it must be posted as a part of the wage determination. The wage rate (including fringe benefits where appropriate) determined pursuant to paragraph 1.c.(3) or (4) of this section must be paid to all workers performing work in the classification under this contract from the first day on which work is performed in the classification.

d. *Fringe benefits not expressed as an hourly rate.* Whenever the minimum wage rate prescribed in the contract for a class of laborers or mechanics includes a fringe benefit which is not expressed as an hourly rate, the contractor may either pay the benefit as stated in the wage determination or may pay another bona fide fringe benefit or an hourly cash equivalent thereof.

e. *Unfunded plans.* If the contractor does not make payments to a trustee or other third person, the contractor may consider as part of the wages of any laborer or mechanic the amount of any costs reasonably anticipated in providing bona fide fringe benefits under a plan or program, *Provided*, That the Secretary of Labor has found, upon the written request of the contractor, in accordance with the criteria set forth in § 5.28, that the applicable standards of the Davis-Bacon Act have been met. The Secretary of Labor may require the contractor to set aside in a separate account assets for the meeting of obligations under the plan or program.

f. *Interest.* In the event of a failure to pay all or part of the wages required by the contract, the contractor will be required to pay interest on any underpayment of wages.

2. Withholding (29 CFR 5.5)

a. *Withholding requirements.* The contracting agency may, upon its own action, or must, upon written request of an authorized representative of the Department of Labor, withhold or cause to be withheld from the contractor so much of the accrued payments or advances as may be considered necessary to satisfy the liabilities of the prime contractor or any subcontractor for the full amount of wages and monetary relief, including interest, required by the clauses set forth in this section for violations of this contract, or to satisfy any such liabilities required by any other Federal contract, or federally assisted contract subject to Davis-Bacon labor standards, that is held by the same prime contractor (as defined in § 5.2). The necessary funds may be withheld from the contractor under this contract, any other Federal contract with the same prime contractor, or any other federally assisted contract that is subject to Davis-Bacon labor standards requirements and is held by the same prime contractor, regardless of whether the other contract was awarded or assisted by the same agency, and such funds may be used to satisfy the contractor liability for which the funds were withheld. In the event of a contractor's failure to pay any laborer or mechanic, including any apprentice or helper working on the site of the work all or part of the wages required by the contract, or upon the contractor's failure to submit the required records as discussed in paragraph 3.d. of this section, the contracting agency may on its own initiative and after written notice to the contractor, take such action as may be necessary to cause the suspension of any further payment, advance, or guarantee of funds until such violations have ceased.

b. *Priority to withheld funds.* The Department has priority to funds withheld or to be withheld in accordance with paragraph

2.a. of this section or Section V, paragraph 3.a., or both, over claims to those funds by:

(1) A contractor's surety(ies), including without limitation performance bond sureties and payment bond sureties;

(2) A contracting agency for its procurement costs;

(3) A trustee(s) (either a court-appointed trustee or a U.S. trustee, or both) in bankruptcy of a contractor, or a contractor's bankruptcy estate;

(4) A contractor's assignee(s);

(5) A contractor's successor(s); or

(6) A claim asserted under the Prompt Payment Act, [31 U.S.C. 3901](#)–3907.

3. Records and certified payrolls (29 CFR 5.5)

a. Basic record requirements (1) Length of record retention. All regular payrolls and other basic records must be maintained by the contractor and any subcontractor during the course of the work and preserved for all laborers and mechanics working at the site of the work (or otherwise working in construction or development of the project under a development statute) for a period of at least 3 years after all the work on the prime contract is completed.

(2) Information required. Such records must contain the name; Social Security number; last known address, telephone number, and email address of each such worker; each worker's correct classification(s) of work actually performed; hourly rates of wages paid (including rates of contributions or costs anticipated for bona fide fringe benefits or cash equivalents thereof of the types described in [40 U.S.C. 3141\(2\)\(B\)](#) of the Davis-Bacon Act); daily and weekly number of hours actually worked in total and on each covered contract; deductions made; and actual wages paid.

(3) Additional records relating to fringe benefits. Whenever the Secretary of Labor has found under paragraph 1.e. of this section that the wages of any laborer or mechanic include the amount of any costs reasonably anticipated in providing benefits under a plan or program described in [40 U.S.C. 3141\(2\)\(B\)](#) of the Davis-Bacon Act, the contractor must maintain records which show that the commitment to provide such benefits is enforceable, that the plan or program is financially responsible, and that the plan or program has been communicated in writing to the laborers or mechanics affected, and records which show the costs anticipated or the actual cost incurred in providing such benefits.

(4) Additional records relating to apprenticeship. Contractors with apprentices working under approved programs must maintain written evidence of the registration of apprenticeship programs, the registration of the apprentices, and the ratios and wage rates prescribed in the applicable programs.

b. Certified payroll requirements (1) Frequency and method of submission. The contractor or subcontractor must submit weekly, for each week in which any DBA- or Related Acts-covered work is performed, certified payrolls to the contracting

agency. The prime contractor is responsible for the submission of all certified payrolls by all subcontractors. A contracting agency or prime contractor may permit or require contractors to submit certified payrolls through an electronic system, as long as the electronic system requires a legally valid electronic signature; the system allows the contractor, the contracting agency, and the Department of Labor to access the certified payrolls upon request for at least 3 years after the work on the prime contract has been completed; and the contracting agency or prime contractor permits other methods of submission in situations where the contractor is unable or limited in its ability to use or access the electronic system.

(2) Information required. The certified payrolls submitted must set out accurately and completely all of the information required to be maintained under paragraph 3.a.(2) of this section, except that full Social Security numbers and last known addresses, telephone numbers, and email addresses must not be included on weekly transmittals. Instead, the certified payrolls need only include an individually identifying number for each worker (e.g., the last four digits of the worker's Social Security number). The required weekly certified payroll information may be submitted using Optional Form WH-347 or in any other format desired. Optional Form WH-347 is available for this purpose from the Wage and Hour Division website at <https://www.dol.gov/sites/dolgov/files/WHDL/legacy/files/wh347.pdf> or its successor website. It is not a violation of this section for a prime contractor to require a subcontractor to provide full Social Security numbers and last known addresses, telephone numbers, and email addresses to the prime contractor for its own records, without weekly submission by the subcontractor to the contracting agency.

(3) Statement of Compliance. Each certified payroll submitted must be accompanied by a "Statement of Compliance," signed by the contractor or subcontractor, or the contractor's or subcontractor's agent who pays or supervises the payment of the persons working on the contract, and must certify the following:

(i) That the certified payroll for the payroll period contains the information required to be provided under paragraph 3.b. of this section, the appropriate information and basic records are being maintained under paragraph 3.a. of this section, and such information and records are correct and complete;

(ii) That each laborer or mechanic (including each helper and apprentice) working on the contract during the payroll period has been paid the full weekly wages earned, without rebate, either directly or indirectly, and that no deductions have been made either directly or indirectly from the full wages earned, other than permissible deductions as set forth in [29 CFR part 3](#); and

(iii) That each laborer or mechanic has been paid not less than the applicable wage rates and fringe benefits or cash equivalents for the classification(s) of work actually performed, as specified in the applicable wage determination incorporated into the contract.

(4) Use of Optional Form WH-347. The weekly submission of a properly executed certification set forth on the reverse side of Optional Form WH-347 will satisfy the requirement for submission of the "Statement of Compliance" required by paragraph 3.b.(3) of this section.

(5) *Signature.* The signature by the contractor, subcontractor, or the contractor's or subcontractor's agent must be an original handwritten signature or a legally valid electronic signature.

(6) *Falsification.* The falsification of any of the above certifications may subject the contractor or subcontractor to civil or criminal prosecution under [18 U.S.C. 1001](#) and [31 U.S.C. 3729](#).

(7) *Length of certified payroll retention.* The contractor or subcontractor must preserve all certified payrolls during the course of the work and for a period of 3 years after all the work on the prime contract is completed.

c. *Contracts, subcontracts, and related documents.* The contractor or subcontractor must maintain this contract or subcontract and related documents including, without limitation, bids, proposals, amendments, modifications, and extensions. The contractor or subcontractor must preserve these contracts, subcontracts, and related documents during the course of the work and for a period of 3 years after all the work on the prime contract is completed.

d. *Required disclosures and access* (1) *Required record disclosures and access to workers.* The contractor or subcontractor must make the records required under paragraphs 3.a. through 3.c. of this section, and any other documents that the contracting agency, the State DOT, the FHWA, or the Department of Labor deems necessary to determine compliance with the labor standards provisions of any of the applicable statutes referenced by § 5.1, available for inspection, copying, or transcription by authorized representatives of the contracting agency, the State DOT, the FHWA, or the Department of Labor, and must permit such representatives to interview workers during working hours on the job.

(2) *Sanctions for non-compliance with records and worker access requirements.* If the contractor or subcontractor fails to submit the required records or to make them available, or refuses to permit worker interviews during working hours on the job, the Federal agency may, after written notice to the contractor, sponsor, applicant, owner, or other entity, as the case may be, that maintains such records or that employs such workers, take such action as may be necessary to cause the suspension of any further payment, advance, or guarantee of funds. Furthermore, failure to submit the required records upon request or to make such records available, or to permit worker interviews during working hours on the job, may be grounds for debarment action pursuant to § 5.12. In addition, any contractor or other person that fails to submit the required records or make those records available to WHD within the time WHD requests that the records be produced will be precluded from introducing as evidence in an administrative proceeding under [29 CFR part 6](#) any of the required records that were not provided or made available to WHD. WHD will take into consideration a reasonable request from the contractor or person for an extension of the time for submission of records. WHD will determine the reasonableness of the request and may consider, among other things, the location of the records and the volume of production.

(3) *Required information disclosures.* Contractors and subcontractors must maintain the full Social Security number and last known address, telephone number, and email address

of each covered worker, and must provide them upon request to the contracting agency, the State DOT, the FHWA, the contractor, or the Wage and Hour Division of the Department of Labor for purposes of an investigation or other compliance action.

4. Apprentices and equal employment opportunity (29 CFR 5.5)

a. *Apprentices (1) Rate of pay.* Apprentices will be permitted to work at less than the predetermined rate for the work they perform when they are employed pursuant to and individually registered in a bona fide apprenticeship program registered with the U.S. Department of Labor, Employment and Training Administration, Office of Apprenticeship (OA), or with a State Apprenticeship Agency recognized by the OA. A person who is not individually registered in the program, but who has been certified by the OA or a State Apprenticeship Agency (where appropriate) to be eligible for probationary employment as an apprentice, will be permitted to work at less than the predetermined rate for the work they perform in the first 90 days of probationary employment as an apprentice in such a program. In the event the OA or a State Apprenticeship Agency recognized by the OA withdraws approval of an apprenticeship program, the contractor will no longer be permitted to use apprentices at less than the applicable predetermined rate for the work performed until an acceptable program is approved.

(2) *Fringe benefits.* Apprentices must be paid fringe benefits in accordance with the provisions of the apprenticeship program. If the apprenticeship program does not specify fringe benefits, apprentices must be paid the full amount of fringe benefits listed on the wage determination for the applicable classification. If the Administrator determines that a different practice prevails for the applicable apprentice classification, fringe benefits must be paid in accordance with that determination.

(3) *Apprenticeship ratio.* The allowable ratio of apprentices to journeyworkers on the job site in any craft classification must not be greater than the ratio permitted to the contractor as to the entire work force under the registered program or the ratio applicable to the locality of the project pursuant to paragraph 4.a.(4) of this section. Any worker listed on a payroll at an apprentice wage rate, who is not registered or otherwise employed as stated in paragraph 4.a.(1) of this section, must be paid not less than the applicable wage rate on the wage determination for the classification of work actually performed. In addition, any apprentice performing work on the job site in excess of the ratio permitted under this section must be paid not less than the applicable wage rate on the wage determination for the work actually performed.

(4) *Reciprocity of ratios and wage rates.* Where a contractor is performing construction on a project in a locality other than the locality in which its program is registered, the ratios and wage rates (expressed in percentages of the journeyworker's hourly rate) applicable within the locality in which the construction is being performed must be observed. If there is no applicable ratio or wage rate for the locality of the project, the ratio and wage rate specified in the contractor's registered program must be observed.

b. *Equal employment opportunity.* The use of apprentices and journeyworkers under this part must be in conformity with

the equal employment opportunity requirements of Executive Order 11246, as amended, and [29 CFR part 30](#).

c. Apprentices and Trainees (programs of the U.S. DOT).

Apprentices and trainees working under apprenticeship and skill training programs which have been certified by the Secretary of Transportation as promoting EEO in connection with Federal-aid highway construction programs are not subject to the requirements of paragraph 4 of this Section IV. 23 CFR 230.111(e)(2). The straight time hourly wage rates for apprentices and trainees under such programs will be established by the particular programs. The ratio of apprentices and trainees to journeyworkers shall not be greater than permitted by the terms of the particular program.

5. Compliance with Copeland Act requirements. The contractor shall comply with the requirements of 29 CFR part 3, which are incorporated by reference in this contract as provided in 29 CFR 5.5.

6. Subcontracts. The contractor or subcontractor must insert FHWA-1273 in any subcontracts, along with the applicable wage determination(s) and such other clauses or contract modifications as the contracting agency may by appropriate instructions require, and a clause requiring the subcontractors to include these clauses and wage determination(s) in any lower tier subcontracts. The prime contractor is responsible for the compliance by any subcontractor or lower tier subcontractor with all the contract clauses in this section. In the event of any violations of these clauses, the prime contractor and any subcontractor(s) responsible will be liable for any unpaid wages and monetary relief, including interest from the date of the underpayment or loss, due to any workers of lower-tier subcontractors, and may be subject to debarment, as appropriate. 29 CFR 5.5.

7. Contract termination: debarment. A breach of the contract clauses in 29 CFR 5.5 may be grounds for termination of the contract, and for debarment as a contractor and a subcontractor as provided in 29 CFR 5.12.

8. Compliance with Davis-Bacon and Related Act requirements. All rulings and interpretations of the Davis-Bacon and Related Acts contained in 29 CFR parts 1, 3, and 5 are herein incorporated by reference in this contract as provided in 29 CFR 5.5.

9. Disputes concerning labor standards. As provided in 29 CFR 5.5, disputes arising out of the labor standards provisions of this contract shall not be subject to the general disputes clause of this contract. Such disputes shall be resolved in accordance with the procedures of the Department of Labor set forth in 29 CFR parts 5, 6, and 7. Disputes within the meaning of this clause include disputes between the contractor (or any of its subcontractors) and the contracting agency, the U.S. Department of Labor, or the employees or their representatives.

10. Certification of eligibility. a. By entering into this contract, the contractor certifies that neither it nor any person or firm who has an interest in the contractor's firm is a person or firm ineligible to be awarded Government contracts by virtue of [40 U.S.C. 3144\(b\)](#) or § 5.12(a).

b. No part of this contract shall be subcontracted to any person or firm ineligible for award of a Government contract by virtue of [40 U.S.C. 3144\(b\)](#) or § 5.12(a).

c. The penalty for making false statements is prescribed in the U.S. Code, Title 18 Crimes and Criminal Procedure, [18 U.S.C. 1001](#).

11. Anti-retaliation. It is unlawful for any person to discharge, demote, intimidate, threaten, restrain, coerce, blacklist, harass, or in any other manner discriminate against, or to cause any person to discharge, demote, intimidate, threaten, restrain, coerce, blacklist, harass, or in any other manner discriminate against, any worker or job applicant for:

a. Notifying any contractor of any conduct which the worker reasonably believes constitutes a violation of the DBA, Related Acts, this part, or [29 CFR part 1](#) or [3](#);

b. Filing any complaint, initiating or causing to be initiated any proceeding, or otherwise asserting or seeking to assert on behalf of themselves or others any right or protection under the DBA, Related Acts, this part, or [29 CFR part 1](#) or [3](#);

c. Cooperating in any investigation or other compliance action, or testifying in any proceeding under the DBA, Related Acts, this part, or [29 CFR part 1](#) or [3](#); or

d. Informing any other person about their rights under the DBA, Related Acts, this part, or [29 CFR part 1](#) or [3](#).

V. CONTRACT WORK HOURS AND SAFETY STANDARDS ACT

Pursuant to 29 CFR 5.5(b), the following clauses apply to any Federal-aid construction contract in an amount in excess of \$100,000 and subject to the overtime provisions of the Contract Work Hours and Safety Standards Act. These clauses shall be inserted in addition to the clauses required by 29 CFR 5.5(a) or 29 CFR 4.6. As used in this paragraph, the terms laborers and mechanics include watchpersons and guards.

1. Overtime requirements. No contractor or subcontractor contracting for any part of the contract work which may require or involve the employment of laborers or mechanics shall require or permit any such laborer or mechanic in any workweek in which he or she is employed on such work to work in excess of forty hours in such workweek unless such laborer or mechanic receives compensation at a rate not less than one and one-half times the basic rate of pay for all hours worked in excess of forty hours in such workweek. 29 CFR 5.5.

2. Violation; liability for unpaid wages; liquidated damages. In the event of any violation of the clause set forth in paragraph 1. of this section the contractor and any subcontractor responsible therefor shall be liable for the unpaid wages and interest from the date of the underpayment. In addition, such contractor and subcontractor shall be liable to the United States (in the case of work done under contract for the District of Columbia or a territory, to such District or to such territory), for liquidated damages. Such liquidated damages shall be computed with respect to each individual laborer or

mechanic, including watchpersons and guards, employed in violation of the clause set forth in paragraph 1. of this section, in the sum currently provided in 29 CFR 5.5(b)(2)* for each calendar day on which such individual was required or permitted to work in excess of the standard workweek of forty hours without payment of the overtime wages required by the clause set forth in paragraph 1. of this section.

* \$31 as of January 15, 2023 (See 88 FR 88 FR 2210) as may be adjusted annually by the Department of Labor, pursuant to the Federal Civil Penalties Inflation Adjustment Act of 1990.

3. Withholding for unpaid wages and liquidated damages

a. *Withholding process.* The FHWA or the contracting agency may, upon its own action, or must, upon written request of an authorized representative of the Department of Labor, withhold or cause to be withheld from the contractor so much of the accrued payments or advances as may be considered necessary to satisfy the liabilities of the prime contractor or any subcontractor for any unpaid wages; monetary relief, including interest; and liquidated damages required by the clauses set forth in this section on this contract, any other Federal contract with the same prime contractor, or any other federally assisted contract subject to the Contract Work Hours and Safety Standards Act that is held by the same prime contractor (as defined in § 5.2). The necessary funds may be withheld from the contractor under this contract, any other Federal contract with the same prime contractor, or any other federally assisted contract that is subject to the Contract Work Hours and Safety Standards Act and is held by the same prime contractor, regardless of whether the other contract was awarded or assisted by the same agency, and such funds may be used to satisfy the contractor liability for which the funds were withheld.

b. *Priority to withheld funds.* The Department has priority to funds withheld or to be withheld in accordance with Section IV paragraph 2.a. or paragraph 3.a. of this section, or both, over claims to those funds by:

- (1) A contractor's surety(ies), including without limitation performance bond sureties and payment bond sureties;
- (2) A contracting agency for its procurement costs;
- (3) A trustee(s) (either a court-appointed trustee or a U.S. trustee, or both) in bankruptcy of a contractor, or a contractor's bankruptcy estate;
- (4) A contractor's assignee(s);
- (5) A contractor's successor(s); or
- (6) A claim asserted under the Prompt Payment Act, [31 U.S.C. 3901](#)–3907.

4. Subcontracts. The contractor or subcontractor must insert in any subcontracts the clauses set forth in paragraphs 1. through 5. of this section and a clause requiring the subcontractors to include these clauses in any lower tier subcontracts. The prime contractor is responsible for compliance by any subcontractor or lower tier subcontractor with the clauses set forth in paragraphs 1. through 5. In the

event of any violations of these clauses, the prime contractor and any subcontractor(s) responsible will be liable for any unpaid wages and monetary relief, including interest from the date of the underpayment or loss, due to any workers of lower-tier subcontractors, and associated liquidated damages and may be subject to debarment, as appropriate.

5. Anti-retaliation. It is unlawful for any person to discharge, demote, intimidate, threaten, restrain, coerce, blacklist, harass, or in any other manner discriminate against, or to cause any person to discharge, demote, intimidate, threaten, restrain, coerce, blacklist, harass, or in any other manner discriminate against, any worker or job applicant for:

a. Notifying any contractor of any conduct which the worker reasonably believes constitutes a violation of the Contract Work Hours and Safety Standards Act (CWHSSA) or its implementing regulations in this part;

b. Filing any complaint, initiating or causing to be initiated any proceeding, or otherwise asserting or seeking to assert on behalf of themselves or others any right or protection under CWHSSA or this part;

c. Cooperating in any investigation or other compliance action, or testifying in any proceeding under CWHSSA or this part; or

d. Informing any other person about their rights under CWHSSA or this part.

VI. SUBLETTING OR ASSIGNING THE CONTRACT

This provision is applicable to all Federal-aid construction contracts on the National Highway System pursuant to 23 CFR 635.116.

1. The contractor shall perform with its own organization contract work amounting to not less than 30 percent (or a greater percentage if specified elsewhere in the contract) of the total original contract price, excluding any specialty items designated by the contracting agency. Specialty items may be performed by subcontract and the amount of any such specialty items performed may be deducted from the total original contract price before computing the amount of work required to be performed by the contractor's own organization (23 CFR 635.116).

a. The term "perform work with its own organization" in paragraph 1 of Section VI refers to workers employed or leased by the prime contractor, and equipment owned or rented by the prime contractor, with or without operators. Such term does not include employees or equipment of a subcontractor or lower tier subcontractor, agents of the prime contractor, or any other assignees. The term may include payments for the costs of hiring leased employees from an employee leasing firm meeting all relevant Federal and State regulatory requirements. Leased employees may only be included in this term if the prime contractor meets all of the following conditions: (based on longstanding interpretation)

- (1) the prime contractor maintains control over the supervision of the day-to-day activities of the leased employees;
- (2) the prime contractor remains responsible for the quality of the work of the leased employees;

(3) the prime contractor retains all power to accept or exclude individual employees from work on the project; and
(4) the prime contractor remains ultimately responsible for the payment of predetermined minimum wages, the submission of payrolls, statements of compliance and all other Federal regulatory requirements.

b. "Specialty Items" shall be construed to be limited to work that requires highly specialized knowledge, abilities, or equipment not ordinarily available in the type of contracting organizations qualified and expected to bid or propose on the contract as a whole and in general are to be limited to minor components of the overall contract. 23 CFR 635.102.

2. Pursuant to 23 CFR 635.116(a), the contract amount upon which the requirements set forth in paragraph (1) of Section VI is computed includes the cost of material and manufactured products which are to be purchased or produced by the contractor under the contract provisions.

3. Pursuant to 23 CFR 635.116(c), the contractor shall furnish (a) a competent superintendent or supervisor who is employed by the firm, has full authority to direct performance of the work in accordance with the contract requirements, and is in charge of all construction operations (regardless of who performs the work) and (b) such other of its own organizational resources (supervision, management, and engineering services) as the contracting officer determines is necessary to assure the performance of the contract.

4. No portion of the contract shall be sublet, assigned or otherwise disposed of except with the written consent of the contracting officer, or authorized representative, and such consent when given shall not be construed to relieve the contractor of any responsibility for the fulfillment of the contract. Written consent will be given only after the contracting agency has assured that each subcontract is evidenced in writing and that it contains all pertinent provisions and requirements of the prime contract. (based on long-standing interpretation of 23 CFR 635.116).

5. The 30-percent self-performance requirement of paragraph (1) is not applicable to design-build contracts; however, contracting agencies may establish their own self-performance requirements. 23 CFR 635.116(d).

VII. SAFETY: ACCIDENT PREVENTION

This provision is applicable to all Federal-aid construction contracts and to all related subcontracts.

1. In the performance of this contract the contractor shall comply with all applicable Federal, State, and local laws governing safety, health, and sanitation (23 CFR Part 635). The contractor shall provide all safeguards, safety devices and protective equipment and take any other needed actions as it determines, or as the contracting officer may determine, to be reasonably necessary to protect the life and health of employees on the job and the safety of the public and to protect property in connection with the performance of the work covered by the contract. 23 CFR 635.108.

2. It is a condition of this contract, and shall be made a condition of each subcontract, which the contractor enters into pursuant to this contract, that the contractor and any subcontractor shall not permit any employee, in performance of the contract, to work in surroundings or under conditions which are unsanitary, hazardous or dangerous to his/her health or safety, as determined under construction safety and

health standards (29 CFR Part 1926) promulgated by the Secretary of Labor, in accordance with Section 107 of the Contract Work Hours and Safety Standards Act (40 U.S.C. 3704). 29 CFR 1926.10.

3. Pursuant to 29 CFR 1926.3, it is a condition of this contract that the Secretary of Labor or authorized representative thereof, shall have right of entry to any site of contract performance to inspect or investigate the matter of compliance with the construction safety and health standards and to carry out the duties of the Secretary under Section 107 of the Contract Work Hours and Safety Standards Act (40 U.S.C. 3704).

VIII. FALSE STATEMENTS CONCERNING HIGHWAY PROJECTS

This provision is applicable to all Federal-aid construction contracts and to all related subcontracts.

In order to assure high quality and durable construction in conformity with approved plans and specifications and a high degree of reliability on statements and representations made by engineers, contractors, suppliers, and workers on Federal-aid highway projects, it is essential that all persons concerned with the project perform their functions as carefully, thoroughly, and honestly as possible. Willful falsification, distortion, or misrepresentation with respect to any facts related to the project is a violation of Federal law. To prevent any misunderstanding regarding the seriousness of these and similar acts, Form FHWA-1022 shall be posted on each Federal-aid highway project (23 CFR Part 635) in one or more places where it is readily available to all persons concerned with the project:

18 U.S.C. 1020 reads as follows:

"Whoever, being an officer, agent, or employee of the United States, or of any State or Territory, or whoever, whether a person, association, firm, or corporation, knowingly makes any false statement, false representation, or false report as to the character, quality, quantity, or cost of the material used or to be used, or the quantity or quality of the work performed or to be performed, or the cost thereof in connection with the submission of plans, maps, specifications, contracts, or costs of construction on any highway or related project submitted for approval to the Secretary of Transportation; or

Whoever knowingly makes any false statement, false representation, false report or false claim with respect to the character, quality, quantity, or cost of any work performed or to be performed, or materials furnished or to be furnished, in connection with the construction of any highway or related project approved by the Secretary of Transportation; or

Whoever knowingly makes any false statement or false representation as to material fact in any statement, certificate, or report submitted pursuant to provisions of the Federal-aid Roads Act approved July 11, 1916, (39 Stat. 355), as amended and supplemented;

Shall be fined under this title or imprisoned not more than 5 years or both."

IX. IMPLEMENTATION OF CLEAN AIR ACT AND FEDERAL WATER POLLUTION CONTROL ACT (42 U.S.C. 7606; 2 CFR 200.88; EO 11738)

This provision is applicable to all Federal-aid construction contracts in excess of \$150,000 and to all related subcontracts. 48 CFR 2.101; 2 CFR 200.327.

By submission of this bid/proposal or the execution of this contract or subcontract, as appropriate, the bidder, proposer, Federal-aid construction contractor, subcontractor, supplier, or vendor agrees to comply with all applicable standards, orders or regulations issued pursuant to the Clean Air Act (42 U.S.C. 7401-7671q) and the Federal Water Pollution Control Act, as amended (33 U.S.C. 1251-1387). Violations must be reported to the Federal Highway Administration and the Regional Office of the Environmental Protection Agency. 2 CFR Part 200, Appendix II.

The contractor agrees to include or cause to be included the requirements of this Section in every subcontract, and further agrees to take such action as the contracting agency may direct as a means of enforcing such requirements. 2 CFR 200.327.

X. CERTIFICATION REGARDING DEBARMENT, SUSPENSION, INELIGIBILITY AND VOLUNTARY EXCLUSION

This provision is applicable to all Federal-aid construction contracts, design-build contracts, subcontracts, lower-tier subcontracts, purchase orders, lease agreements, consultant contracts or any other covered transaction requiring FHWA approval or that is estimated to cost \$25,000 or more – as defined in 2 CFR Parts 180 and 1200. 2 CFR 180.220 and 1200.220.

1. Instructions for Certification – First Tier Participants:

a. By signing and submitting this proposal, the prospective first tier participant is providing the certification set out below.

b. The inability of a person to provide the certification set out below will not necessarily result in denial of participation in this covered transaction. The prospective first tier participant shall submit an explanation of why it cannot provide the certification set out below. The certification or explanation will be considered in connection with the department or agency's determination whether to enter into this transaction. However, failure of the prospective first tier participant to furnish a certification or an explanation shall disqualify such a person from participation in this transaction. 2 CFR 180.320.

c. The certification in this clause is a material representation of fact upon which reliance was placed when the contracting agency determined to enter into this transaction. If it is later determined that the prospective participant knowingly rendered an erroneous certification, in addition to other remedies available to the Federal Government, the contracting agency may terminate this transaction for cause of default. 2 CFR 180.325.

d. The prospective first tier participant shall provide immediate written notice to the contracting agency to whom this proposal is submitted if any time the prospective first tier participant learns that its certification was erroneous when submitted or has become erroneous by reason of changed circumstances. 2 CFR 180.345 and 180.350.

e. The terms "covered transaction," "debarred," "suspended," "ineligible," "participant," "person," "principal," and "voluntarily excluded," as used in this clause, are defined in 2 CFR Parts 180, Subpart I, 180.900-180.1020, and 1200. "First Tier Covered Transactions" refers to any covered transaction between a recipient or subrecipient of Federal funds and a participant (such as the prime or general contract). "Lower Tier Covered Transactions" refers to any covered transaction under a First Tier Covered Transaction (such as subcontracts). "First Tier Participant" refers to the participant who has entered into a covered transaction with a recipient or subrecipient of Federal funds (such as the prime or general contractor). "Lower Tier Participant" refers any participant who has entered into a covered transaction with a First Tier Participant or other Lower Tier Participants (such as subcontractors and suppliers).

f. The prospective first tier participant agrees by submitting this proposal that, should the proposed covered transaction be entered into, it shall not knowingly enter into any lower tier covered transaction with a person who is debarred, suspended, declared ineligible, or voluntarily excluded from participation in this covered transaction, unless authorized by the department or agency entering into this transaction. 2 CFR 180.330.

g. The prospective first tier participant further agrees by submitting this proposal that it will include the clause titled "Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion-Lower Tier Covered Transactions," provided by the department or contracting agency, entering into this covered transaction, without modification, in all lower tier covered transactions and in all solicitations for lower tier covered transactions exceeding the \$25,000 threshold. 2 CFR 180.220 and 180.300.

h. A participant in a covered transaction may rely upon a certification of a prospective participant in a lower tier covered transaction that is not debarred, suspended, ineligible, or voluntarily excluded from the covered transaction, unless it knows that the certification is erroneous. 2 CFR 180.300; 180.320, and 180.325. A participant is responsible for ensuring that its principals are not suspended, debarred, or otherwise ineligible to participate in covered transactions. 2 CFR 180.335. To verify the eligibility of its principals, as well as the eligibility of any lower tier prospective participants, each participant may, but is not required to, check the System for Award Management website (<https://www.sam.gov/>). 2 CFR 180.300, 180.320, and 180.325.

i. Nothing contained in the foregoing shall be construed to require the establishment of a system of records in order to render in good faith the certification required by this clause. The knowledge and information of the prospective participant is not required to exceed that which is normally possessed by a prudent person in the ordinary course of business dealings.

j. Except for transactions authorized under paragraph (f) of these instructions, if a participant in a covered transaction knowingly enters into a lower tier covered transaction with a person who is suspended, debarred, ineligible, or voluntarily excluded from participation in this transaction, in addition to other remedies available to the Federal Government, the department or agency may terminate this transaction for cause or default. 2 CFR 180.325.

* * * * *

2. Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion – First Tier Participants:

a. The prospective first tier participant certifies to the best of its knowledge and belief, that it and its principals:

(1) Are not presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from participating in covered transactions by any Federal department or agency, 2 CFR 180.335;.

(2) Have not within a three-year period preceding this proposal been convicted of or had a civil judgment rendered against them for commission of fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a public (Federal, State, or local) transaction or contract under a public transaction; violation of Federal or State antitrust statutes or commission of embezzlement, theft, forgery, bribery, falsification or destruction of records, making false statements, or receiving stolen property, 2 CFR 180.800;

(3) Are not presently indicted for or otherwise criminally or civilly charged by a governmental entity (Federal, State or local) with commission of any of the offenses enumerated in paragraph (a)(2) of this certification, 2 CFR 180.700 and 180.800; and

(4) Have not within a three-year period preceding this application/proposal had one or more public transactions (Federal, State or local) terminated for cause or default. 2 CFR 180.335(d).

(5) Are not a corporation that has been convicted of a felony violation under any Federal law within the two-year period preceding this proposal (USDOT Order 4200.6 implementing appropriations act requirements); and

(6) Are not a corporation with any unpaid Federal tax liability that has been assessed, for which all judicial and administrative remedies have been exhausted, or have lapsed, and that is not being paid in a timely manner pursuant to an agreement with the authority responsible for collecting the tax liability (USDOT Order 4200.6 implementing appropriations act requirements).

b. Where the prospective participant is unable to certify to any of the statements in this certification, such prospective participant should attach an explanation to this proposal. 2 CFR 180.335 and 180.340.

3. Instructions for Certification - Lower Tier Participants:

(Applicable to all subcontracts, purchase orders, and other lower tier transactions requiring prior FHWA approval or estimated to cost \$25,000 or more - 2 CFR Parts 180 and 1200). 2 CFR 180.220 and 1200.220.

a. By signing and submitting this proposal, the prospective lower tier participant is providing the certification set out below.

b. The certification in this clause is a material representation of fact upon which reliance was placed when this transaction was entered into. If it is later determined that the prospective lower tier participant knowingly rendered an erroneous certification, in addition to other remedies available to the Federal Government, the department, or agency with which

this transaction originated may pursue available remedies, including suspension and/or debarment.

c. The prospective lower tier participant shall provide immediate written notice to the person to which this proposal is submitted if at any time the prospective lower tier participant learns that its certification was erroneous by reason of changed circumstances. 2 CFR 180.365.

d. The terms "covered transaction," "debarred," "suspended," "ineligible," "participant," "person," "principal," and "voluntarily excluded," as used in this clause, are defined in 2 CFR Parts 180, Subpart I, 180.900 – 180.1020, and 1200. You may contact the person to which this proposal is submitted for assistance in obtaining a copy of those regulations. "First Tier Covered Transactions" refers to any covered transaction between a recipient or subrecipient of Federal funds and a participant (such as the prime or general contractor). "Lower Tier Covered Transactions" refers to any covered transaction under a First Tier Covered Transaction (such as subcontracts). "First Tier Participant" refers to the participant who has entered into a covered transaction with a recipient or subrecipient of Federal funds (such as the prime or general contractor). "Lower Tier Participant" refers any participant who has entered into a covered transaction with a First Tier Participant or other Lower Tier Participants (such as subcontractors and suppliers).

e. The prospective lower tier participant agrees by submitting this proposal that, should the proposed covered transaction be entered into, it shall not knowingly enter into any lower tier covered transaction with a person who is debarred, suspended, declared ineligible, or voluntarily excluded from participation in this covered transaction, unless authorized by the department or agency with which this transaction originated. 2 CFR 1200.220 and 1200.332.

f. The prospective lower tier participant further agrees by submitting this proposal that it will include this clause titled "Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion-Lower Tier Covered Transaction," without modification, in all lower tier covered transactions and in all solicitations for lower tier covered transactions exceeding the \$25,000 threshold. 2 CFR 180.220 and 1200.220.

g. A participant in a covered transaction may rely upon a certification of a prospective participant in a lower tier covered transaction that is not debarred, suspended, ineligible, or voluntarily excluded from the covered transaction, unless it knows that the certification is erroneous. A participant is responsible for ensuring that its principals are not suspended, debarred, or otherwise ineligible to participate in covered transactions. To verify the eligibility of its principals, as well as the eligibility of any lower tier prospective participants, each participant may, but is not required to, check the System for Award Management website (<https://www.sam.gov/>), which is compiled by the General Services Administration. 2 CFR 180.300, 180.320, 180.330, and 180.335.

h. Nothing contained in the foregoing shall be construed to require establishment of a system of records in order to render in good faith the certification required by this clause. The knowledge and information of participant is not required to exceed that which is normally possessed by a prudent person in the ordinary course of business dealings.

i. Except for transactions authorized under paragraph e of these instructions, if a participant in a covered transaction knowingly enters into a lower tier covered transaction with a person who is suspended, debarred, ineligible, or voluntarily

excluded from participation in this transaction, in addition to other remedies available to the Federal Government, the department or agency with which this transaction originated may pursue available remedies, including suspension and/or debarment. 2 CFR 180.325.

* * * * *

4. Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion--Lower Tier Participants:

a. The prospective lower tier participant certifies, by submission of this proposal, that neither it nor its principals:

(1) is presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from participating in covered transactions by any Federal department or agency, 2 CFR 180.355;

(2) is a corporation that has been convicted of a felony violation under any Federal law within the two-year period preceding this proposal (USDOT Order 4200.6 implementing appropriations act requirements); and

(3) is a corporation with any unpaid Federal tax liability that has been assessed, for which all judicial and administrative remedies have been exhausted, or have lapsed, and that is not being paid in a timely manner pursuant to an agreement with the authority responsible for collecting the tax liability. (USDOT Order 4200.6 implementing appropriations act requirements)

b. Where the prospective lower tier participant is unable to certify to any of the statements in this certification, such prospective participant should attach an explanation to this proposal.

* * * * *

XI. CERTIFICATION REGARDING USE OF CONTRACT FUNDS FOR LOBBYING

This provision is applicable to all Federal-aid construction contracts and to all related subcontracts which exceed \$100,000. 49 CFR Part 20, App. A.

1. The prospective participant certifies, by signing and submitting this bid or proposal, to the best of his or her knowledge and belief, that:

a. No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any Federal agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

b. If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any Federal agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or

cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions.

2. This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by 31 U.S.C. 1352. Any person who fails to file the required certification shall be subject to a civil penalty of not less than \$10,000 and not more than \$100,000 for each such failure.

3. The prospective participant also agrees by submitting its bid or proposal that the participant shall require that the language of this certification be included in all lower tier subcontracts, which exceed \$100,000 and that all such recipients shall certify and disclose accordingly.

XII. USE OF UNITED STATES-FLAG VESSELS:

This provision is applicable to all Federal-aid construction contracts, design-build contracts, subcontracts, lower-tier subcontracts, purchase orders, lease agreements, or any other covered transaction. 46 CFR Part 381.

This requirement applies to material or equipment that is acquired for a specific Federal-aid highway project. 46 CFR 381.7. It is not applicable to goods or materials that come into inventories independent of an FHWA funded-contract.

When oceanic shipments (or shipments across the Great Lakes) are necessary for materials or equipment acquired for a specific Federal-aid construction project, the bidder, proposer, contractor, subcontractor, or vendor agrees:

1. To utilize privately owned United States-flag commercial vessels to ship at least 50 percent of the gross tonnage (computed separately for dry bulk carriers, dry cargo liners, and tankers) involved, whenever shipping any equipment, material, or commodities pursuant to this contract, to the extent such vessels are available at fair and reasonable rates for United States-flag commercial vessels. 46 CFR 381.7.

2. To furnish within 20 days following the date of loading for shipments originating within the United States or within 30 working days following the date of loading for shipments originating outside the United States, a legible copy of a rated, 'on-board' commercial ocean bill-of-lading in English for each shipment of cargo described in paragraph (b)(1) of this section to both the Contracting Officer (through the prime contractor in the case of subcontractor bills-of-lading) and to the Office of Cargo and Commercial Sealift (MAR-620), Maritime Administration, Washington, DC 20590. (MARAD requires copies of the ocean carrier's (master) bills of lading, certified onboard, dated, with rates and charges. These bills of lading may contain business sensitive information and therefore may be submitted directly to MARAD by the Ocean Transportation Intermediary on behalf of the contractor). 46 CFR 381.7.

**ATTACHMENT A - EMPLOYMENT AND MATERIALS
PREFERENCE FOR APPALACHIAN DEVELOPMENT
HIGHWAY SYSTEM OR APPALACHIAN LOCAL ACCESS
ROAD CONTRACTS (23 CFR 633, Subpart B, Appendix B)**

This provision is applicable to all Federal-aid projects funded under the Appalachian Regional Development Act of 1965.

1. During the performance of this contract, the contractor undertaking to do work which is, or reasonably may be, done as on-site work, shall give preference to qualified persons who regularly reside in the labor area as designated by the DOL wherein the contract work is situated, or the subregion, or the Appalachian counties of the State wherein the contract work is situated, except:

a. To the extent that qualified persons regularly residing in the area are not available.

b. For the reasonable needs of the contractor to employ supervisory or specially experienced personnel necessary to assure an efficient execution of the contract work.

c. For the obligation of the contractor to offer employment to present or former employees as the result of a lawful collective bargaining contract, provided that the number of nonresident persons employed under this subparagraph (1c) shall not exceed 20 percent of the total number of employees employed by the contractor on the contract work, except as provided in subparagraph (4) below.

2. The contractor shall place a job order with the State Employment Service indicating (a) the classifications of the laborers, mechanics and other employees required to perform the contract work, (b) the number of employees required in each classification, (c) the date on which the participant estimates such employees will be required, and (d) any other pertinent information required by the State Employment Service to complete the job order form. The job order may be placed with the State Employment Service in writing or by telephone. If during the course of the contract work, the information submitted by the contractor in the original job order is substantially modified, the participant shall promptly notify the State Employment Service.

3. The contractor shall give full consideration to all qualified job applicants referred to him by the State Employment Service. The contractor is not required to grant employment to any job applicants who, in his opinion, are not qualified to perform the classification of work required.

4. If, within one week following the placing of a job order by the contractor with the State Employment Service, the State Employment Service is unable to refer any qualified job applicants to the contractor, or less than the number requested, the State Employment Service will forward a certificate to the contractor indicating the unavailability of applicants. Such certificate shall be made a part of the contractor's permanent project records. Upon receipt of this certificate, the contractor may employ persons who do not normally reside in the labor area to fill positions covered by the certificate, notwithstanding the provisions of subparagraph (1c) above.

5. The provisions of 23 CFR 633.207(e) allow the contracting agency to provide a contractual preference for the use of mineral resource materials native to the Appalachian region.

6. The contractor shall include the provisions of Sections 1 through 4 of this Attachment A in every subcontract for work which is, or reasonably may be, done as on-site work.

I. WAGE RATES

The wage rates listed herein are those predetermined by the Secretary of Labor and State Statute and listed in the United States Department of Labor's (USDOL) General Decisions dated 01-06-2023 and are the minimum wages to be paid accordingly for each specified classification. To determine the applicable wage rate zone, a list entitled "TEXAS COUNTIES IDENTIFIED BY WAGE RATE ZONES" is provided in the contract. Any wage rate that is not listed herein and not in the USDOL's general decision, must be submitted to the Engineer for approval. IMPORTANT NOTICE FOR STATE PROJECTS: only the controlling wage rate zone applies to the contract. Effective 01-06-2023.

CLASS #	CLASSIFICATION DESCRIPTION	ZONE TX02 (TX20230002)	ZONE TX03 (TX20230003)	ZONE TX04 (TX20230004)	ZONE TX05 (TX20230005)	ZONE TX06 (TX20230006)	ZONE TX07 (TX20230007)	ZONE TX08 (TX20230008)	ZONE TX09 (TX20230009)	ZONE TX10 (TX20230010)	ZONE TX11 (TX20230011)	ZONE TX12 (TX20230012)	ZONE TX13 (TX20230013)	ZONE TX14 (TX20230014)	ZONE TX15 (TX20230015)	ZONE TX16 (TX20230016)	ZONE TX17 (TX20230017)	ZONE TX18 (TX20230018)	ZONE TX19 (TX20230019)	ZONE TX20 (TX20230020)	ZONE TX21 (TX20230021)	ZONE TX22 (TX20230022)	ZONE TX23 (TX20230023)	ZONE TX24 (TX20230024)	ZONE TX25 (TX20230025)	ZONE TX26 (TX20230026)	ZONE TX27 (TX20230027)	ZONE TX28 (TX20230028)	ZONE TX29 (TX20230029)	ZONE TX30 (TX20230030)	ZONE TX31 (TX20230031)	ZONE TX32 (TX20230032)	ZONE TX33 (TX20230033)	ZONE TX34 (TX20230034)		
1428	Agricultural Tractor Operator																																			
1300	Asphalt Distributor Operator	\$14.67	\$13.46	\$13.88	\$16.72	\$15.56	\$15.56	\$15.72	\$13.28	\$13.28	\$15.32	\$15.62	\$14.36	\$14.25	\$14.03	\$11.75	\$13.75	\$14.06																		
1303	Asphalt Paving Machine Operator	\$13.40	\$12.25	\$12.35	\$13.87	\$14.06	\$14.38	\$14.20	\$13.26	\$13.26	\$13.58	\$14.65	\$12.92	\$13.44	\$12.53	\$14.00	\$12.88	\$14.32	\$12.99	\$14.00	\$14.32	\$12.99	\$12.55	\$12.55	\$14.00	\$14.32	\$12.99	\$12.55	\$11.67	\$11.67	\$11.40	\$12.55	\$12.36	\$11.78		
1106	Asphalt Raker	\$12.28	\$10.61	\$12.02	\$14.21	\$11.65	\$12.12	\$11.64	\$11.44	\$11.44	\$12.69	\$12.05	\$11.34	\$11.67	\$11.40	\$12.56	\$12.36	\$11.78																		
1112	Batching Plant Operator, Asphalt																																			
1115	Batching Plant Operator, Concrete																																			
1214	Blaster																																			
1615	Boom Truck Operator						\$18.36																													
1444	Boring Machine Operator																																			
1305	Broom or Sweeper Operator	\$11.21	\$10.33	\$10.08	\$11.99		\$11.04	\$11.62																												
1144	Communications Cable Installer																																			
1124	Concrete Barrier Paving and Structures	\$13.55	\$12.46	\$13.16	\$12.85	\$12.64	\$12.56	\$12.77	\$12.44	\$14.12	\$13.04																									
1316	Concrete Pavement Finishing Machine																																			
1318	Concrete Paving, Curing, Hobbit, Texturing				\$16.05		\$15.48				\$16.05							\$19.31																		
1315	Machine Operator																																			
1333	Concrete Saw Operator							\$14.67										\$16.34																		
1399	Concrete/Grout Pump Operator																																			
1344	Crane Operator Hydraulic 80 tons or less				\$16.22													\$20.21																		
1345	Crane Operator Hydraulic Over 80 Tons																																			
1342	Crane Operator, Lattice Boom Over 80 Tons or Less	\$16.62	\$14.39	\$13.85	\$17.27		\$15.67				\$17.27							\$14.67																		
1343	Crane Operator, Lattice Boom Over 80 Tons				\$20.52		\$19.36				\$20.52							\$17.45																		
1306	Crawler Tractor Operator	\$13.96	\$16.63	\$13.62	\$14.26		\$15.67				\$14.07	\$13.15	\$13.38				\$12.88																			
1351	Cluster or Screen Plant Operator																																			
1446	Directional Drilling Locator							\$11.67																												
1445	Directional Drilling Operator				\$20.32		\$17.24																													
1139	Electrician	\$20.96		\$19.87	\$19.80		\$26.35				\$20.27	\$15.80		\$20.92				\$27.11	\$19.67																	
1347	Excavator Operator, 50,000 pounds or less	\$13.46	\$12.56	\$13.67	\$17.19		\$12.88	\$14.38	\$13.49	\$17.19			\$13.88					\$14.09	\$12.71	\$14.42																
1348	Excavator Operator, Over 50,000 pounds		\$15.23	\$13.52	\$17.04		\$17.71																													
1150	Flagger	\$9.50	\$8.10	\$8.50	\$10.28	\$8.81	\$9.45	\$8.70										\$8.03	\$5.81	\$9.05	\$9.80	\$10.33	\$8.10	\$9.80	\$10.33	\$8.10	\$9.80	\$10.33	\$8.10	\$9.80	\$10.33	\$8.10	\$9.80	\$10.33		
1151	Form Builder/Seller, Structures	\$13.52	\$12.30	\$13.38	\$12.91	\$12.71	\$12.87	\$12.38	\$12.26		\$13.84	\$12.58	\$13.07	\$13.61	\$12.82	\$14.73	\$12.23	\$12.37	\$12.55	\$12.82	\$12.55	\$12.37	\$12.55	\$12.37	\$12.55	\$12.37	\$12.55	\$12.37	\$12.55	\$12.37	\$12.55	\$12.37	\$12.55	\$12.37		
1160	Form Setter, Paving & Curb	\$12.36	\$12.16	\$13.93	\$11.83	\$10.71	\$12.94				\$13.16	\$12.54	\$11.33	\$10.69		\$13.33	\$12.34	\$13.33	\$12.34	\$13.33	\$12.34	\$13.33	\$12.34	\$13.33	\$12.34	\$13.33	\$12.34	\$13.33	\$12.34	\$13.33	\$12.34	\$13.33	\$12.34	\$13.33		
1350	Foundation Unit Operator, Mounted				\$17.99						\$17.99																									
1363	Foundation Unit Operator, Truck Mounted		\$16.86	\$22.05	\$21.51		\$16.93				\$21.07	\$20.20	\$20.76		\$17.54	\$21.36	\$15.99	\$22.05																		
1369	Front End Loader Operator, 3 CY or Less	\$12.26	\$13.49	\$13.40	\$13.85		\$13.04	\$13.15	\$13.29	\$13.69	\$12.64	\$12.85						\$13.51	\$13.32	\$12.17																
1372	Front End Loader Operator, Over 3 CY	\$12.77	\$13.69	\$12.33	\$14.96		\$13.21	\$12.86	\$13.57	\$14.72		\$13.75	\$12.32					\$13.19	\$13.17	\$13.02																
1329	Joint Sealer																																			
1172	Laborer, Common	\$10.50	\$8.86	\$10.08	\$10.51	\$10.71	\$10.50	\$10.24	\$10.56	\$10.72	\$10.45	\$10.30	\$10.25	\$10.03	\$10.54	\$11.02	\$10.15																			
1175	Laborer, Utility	\$11.80	\$11.53	\$12.70	\$12.17	\$11.81	\$12.27	\$12.11	\$11.53	\$12.32	\$11.80	\$11.53	\$11.23	\$11.50	\$11.56	\$11.73	\$12.37	\$11.50	\$11.73	\$12.37	\$11.50	\$11.73	\$12.37	\$11.50	\$11.73	\$12.37	\$11.50	\$11.73	\$12.37	\$11.50	\$11.73	\$12.37	\$11.50	\$11.73		
1346	Loader/Backhoe Operator	\$14.18	\$12.97	\$12.97	\$16.68		\$14.12				\$15.18	\$13.58	\$12.87	\$14.13	\$14.29	\$14.13	\$14.29	\$12.90	\$17.47	\$12.90	\$17.47	\$12.90	\$17.47	\$12.90	\$17.47	\$12.90	\$17.47	\$12.90	\$17.47	\$12.90	\$17.47	\$12.90	\$17.47	\$12.90	\$17.47	
1187	Mechanic	\$20.14	\$15.47	\$17.47	\$17.74	\$17.00					\$17.68	\$18.94	\$18.58	\$17.00	\$18.61	\$18.46	\$16.96	\$17.47	\$18.46	\$16.96	\$17.47	\$18.46	\$16.96	\$17.47	\$18.46	\$16.96	\$17.47	\$18.46	\$16.96	\$17.47	\$18.46	\$16.96	\$17.47	\$18.46		
1380	Milling Machine Operator	\$15.64	\$14.64	\$12.22	\$14.29		\$14.18				\$14.32	\$14.35	\$12.86					\$14.75	\$13.53	\$12.80																

CLASS #	CLASSIFICATION DESCRIPTION	ZONE TX02 (TX02Z0002)	ZONE TX03 (TX02Z0003)	ZONE TX04 (TX02Z0004)	ZONE TX05 (TX02Z0005)	ZONE TX06 (TX02Z0006)	ZONE TX07 (TX02Z0007)	ZONE TX08 (TX02Z0008)	ZONE TX09 (TX02Z0009)	ZONE TX10 (TX02Z0010)	ZONE TX11 (TX02Z0011)	ZONE TX12 (TX02Z0012)	ZONE TX13 (TX02Z0013)	ZONE TX14 (TX02Z0014)	ZONE TX15 (TX02Z0015)	ZONE TX16 (TX02Z0016)	ZONE TX17 (TX02Z0017)	ZONE TX18 (TX02Z0018)	ZONE TX19 (TX02Z0019)	ZONE TX20 (TX02Z0020)	ZONE TX21 (TX02Z0021)	ZONE TX22 (TX02Z0022)	ZONE TX23 (TX02Z0023)	ZONE TX24 (TX02Z0024)	ZONE TX25 (TX02Z0025)	ZONE TX26 (TX02Z0026)	ZONE TX27 (TX02Z0027)	ZONE TX28 (TX02Z0028)	ZONE TX29 (TX02Z0029)	ZONE TX30 (TX02Z0030)	ZONE TX31 (TX02Z0031)	ZONE TX32 (TX02Z0032)	ZONE TX33 (TX02Z0033)	ZONE TX34 (TX02Z0034)	ZONE TX35 (TX02Z0035)	ZONE TX36 (TX02Z0036)	ZONE TX37 (TX02Z0037)	ZONE TX38 (TX02Z0038)	ZONE TX39 (TX02Z0039)	ZONE TX40 (TX02Z0040)	ZONE TX41 (TX02Z0041)	ZONE TX42 (TX02Z0042)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
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Notes:

*R represents the USDOT wage decision.

Any worker employed on this project shall be paid at the rate of one and one half (1-1/2) times the regular rate for every hour worked in excess of forty (40) hours per week.

For reference, the titles and descriptions for the classifications listed here are detailed further in the AGC of Texas' *Standard Job Classifications and Descriptions for Highway, Heavy, Utilities and Industrial Construction in Texas* posted on the AGC's Web site for any contractor.

**TEXAS COUNTIES IDENTIFIED BY
WAGE RATE ZONES: 2, 3, 4, 5, 6, 7, 8, 24, 25, 27, 28, 29, 30, 37, 38, 42**

County Name	Zone	County Name	Zone	County Name	Zone	County Name	Zone
Anderson	28	Donley	37	Karnes	27	Reagan	37
Andrews	37	Duval	30	Kaufman	25	Real	37
Angelina	28	Eastland	37	Kendall	7	Red River	28
Aransas	29	Ector	2	Kenedy	30	Reeves	8
Archer	25	Edwards	8	Kent	37	Refugio	27
Armstrong	2	El Paso	24	Kerr	27	Roberts	37
Atascosa	7	Ellis	25	Kimble	37	Robertson	7
Austin	38	Erath	28	King	37	Rockwall	25
Bailey	37	Falls	28	Kinney	8	Runnels	37
Bandera	7	Fannin	28	Kleberg	27	Rusk	4
Bastrop	7	Fayette	27	Knox	37	Sabine	28
Baylor	37	Fisher	37	Lamar	28	San Augustine	28
Bee	27	Floyd	37	Lamb	37	San Jacinto	38
Bell	7	Foard	37	Lampasas	7	San Patricio	29
Bexar	7	Fort Bend	38	LaSalle	30	San Saba	37
Blanco	27	Franklin	28	Lavaca	27	Schleicher	37
Borden	37	Freestone	28	Lee	27	Scurry	37
Bosque	28	Frio	27	Leon	28	Shackelford	37
Bowie	4	Gaines	37	Liberty	38	Shelby	28
Brazoria	38	Galveston	38	Limestone	28	Sherman	37
Brazos	7	Garza	37	Lipscomb	37	Smith	4
Brewster	8	Gillespie	27	Live Oak	27	Somervell	28
Briscoe	37	Glasscock	37	Llano	27	Starr	30
Brooks	30	Goliad	29	Loving	37	Stephens	37
Brown	37	Gonzales	27	Lubbock	2	Sterling	37
Burleson	7	Gray	37	Lynn	37	Stonewall	37
Burnet	27	Grayson	25	Madison	28	Sutton	8
Caldwell	7	Gregg	4	Marion	28	Swisher	37
Calhoun	29	Grimes	28	Martin	37	Tarrant	25
Callahan	25	Guadalupe	7	Mason	27	Taylor	2
Cameron	3	Hale	37	Matagorda	27	Terrell	8
Camp	28	Hall	37	Maverick	30	Terry	37
Carson	2	Hamilton	28	McCulloch	37	Throckmorton	37
Cass	28	Hansford	37	McLennan	7	Titus	28
Castro	37	Hardeman	37	McMullen	30	Tom Green	2
Chambers	38	Hardin	38	Medina	7	Travis	7
Cherokee	28	Harris	38	Menard	37	Trinity	28
Childress	37	Harrison	42	Midland	2	Tyler	28
Clay	25	Hartley	37	Milam	28	Upshur	4
Cochran	37	Haskell	37	Mills	37	Upton	37
Coke	37	Hays	7	Mitchell	37	Uvalde	30
Coleman	37	Hemphill	37	Montague	37	Val Verde	8
Collin	25	Henderson	28	Montgomery	38	Van Zandt	28
Collingsworth	37	Hidalgo	3	Moore	37	Victoria	6
Colorado	27	Hill	28	Morris	28	Walker	28
Comal	7	Hockley	37	Motley	37	Waller	38
Comanche	37	Hood	28	Nacogdoches	28	Ward	37
Concho	37	Hopkins	28	Navarro	28	Washington	28
Cooke	37	Houston	28	Newton	28	Webb	3
Coryell	7	Howard	37	Nolan	37	Wharton	27
Cottle	37	Hudspeth	8	Nueces	29	Wheeler	37
Crane	37	Hunt	25	Ochiltree	37	Wichita	5
Crockett	8	Hutchinson	37	Oldham	37	Wilbarger	37
Crosby	2	Irion	2	Orange	38	Willacy	30
Culberson	8	Jack	28	Palo Pinto	28	Williamson	7
Dallam	37	Jackson	27	Panola	28	Wilson	7
Dallas	25	Jasper	28	Parker	25	Winkler	37
Dawson	37	Jeff Davis	8	Parmer	37	Wise	25
Deaf Smith	37	Jefferson	38	Pecos	8	Wood	28
Delta	25	Jim Hogg	30	Polk	28	Yoakum	37
Denton	25	Jim Wells	27	Potter	2	Young	37
DeWitt	27	Johnson	25	Presidio	8	Zapata	30
Dickens	37	Jones	25	Rains	28	Zavala	30
Dimmit	30			Randall	2		

01/06/2023

**J. EXAMPLE OF BID PRICES SUBMITTED BY COMPUTER
PRINTOUT**

BASE BID I UNIT PRICE SCHEDULE								
TXDOT CSJ: 0924-06-564								
STP 2021 (088) MM								
NO.	ITEM-CODE		BRIEF DESCRIPTION OF ITEM	UNIT	QTY.	UNIT PRICE	TOTAL AMOUNT	DEPT USE ONLY
	ITEM - NO.	S.P. NO.						
49	529	6004	CONC CURB (MONO) (TY I)	LF	200	\$ _____	\$ _____	
50	529	6005	CONC CURB (MONO) (TY II)	LF	30637	\$ _____	\$ _____	
51	529	6008	CONC CURB & GUTTER (TY II)	LF	2396	\$ _____	\$ _____	
52	530	6004	DRIVEWAYS (CONC)	SY	760	\$ _____	\$ _____	
53	538	6001	RIGHT OF WAY MARKERS	EA	2	\$ _____	\$ _____	
54	542	6001	REMOVE METAL BEAM GUARD FENCE	LF	57	\$ _____	\$ _____	
55	550	6001	CHAIN LINK FENCE (INSTALL) (6')	LF	339	\$ _____	\$ _____	
56	550	6006	GATE (REMOVE)	EA	1	\$ _____	\$ _____	
57	550	6013	CHAIN LINK FENCE GATE (INSTALL)(6'X10')	EA	4	\$ _____	\$ _____	
58	ELP1	6001	POND DEPTH GAUGE	EA	3	\$ _____	\$ _____	
59	ELP2	6001	STONE MASONRY (ROCK WALL)	LF	333	\$ _____	\$ _____	
60	ELP3	6001	WROUGHT IRON GATE	EA	1	\$ _____	\$ _____	
61	ELP4	6001	CORATIVE ILLUMINATION ASSEMBLY (6'-6") DUAL AR	EA	10	\$ _____	\$ _____	
62	ELP5	6001	FIXED BOLLARDS	EA	20	\$ _____	\$ _____	
63	ELP6	6001	PIPE (PVC) (SCH40) (2 IN)	LF	1050	\$ _____	\$ _____	
64	ELP6	6002	PIPE (PVC) (SCH40) (6 IN)	LF	525	\$ _____	\$ _____	
65	ELP7	6001	VALVE BOX	EA	54	\$ _____	\$ _____	
66	ELP8	6001	CASING PIPE (BORE) (60" FIBER GLASS)	LF	21	\$ _____	\$ _____	
67	ELP8	6002	CASING PIPE (BORE) (72" FIBER GLASS)	LF	56	\$ _____	\$ _____	
68	ELP9	6001	HDPE PIPE (42")	LF	345	\$ _____	\$ _____	
69	ELP9	6002	HDPE PIPE (48")	LF	460	\$ _____	\$ _____	
70	ELPA	6001	SWING GATE	EA	4	\$ _____	\$ _____	
71	ELPB	6001	WATER FILLED BARRIER (350)(TL-3)	LF	2717	\$ _____	\$ _____	
72	618	6023	CONDT (PVC) (SCH 40) (2")	LF	7130	\$ _____	\$ _____	

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STP 2021 (088) MM								
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	ITEM NO.	S.P. NO.						
73	618	6047	CONDT (PVC) (SCH 80) (2") (BORE)	LF	515	\$ _____	\$ _____	
74	620	6010	ELEC CONDR (NO.6) INSULATED	LF	24160	\$ _____	\$ _____	
75	624	6002	GROUND BOX TY A (122311)W/APRON	EA	43	\$ _____	\$ _____	
76	628	6041	ELC SRV TY A 240/480 060(NS)SS(E)GC(O)	EA	3	\$ _____	\$ _____	
77	636	6001	ALUMINUM SIGNS (TY A)	SF	50	\$ _____	\$ _____	
78	644	6001	IN SM RD SN SUP&AM TY10BWG(1)SA(P)	EA	14	\$ _____	\$ _____	
79	644	6004	IN SM RD SN SUP&AM TY10BWG(1)SA(T)	EA	1	\$ _____	\$ _____	
80	658	6083	INSTL DEL ASSM (D-SW)SZ 1(WFLX)SRF	EA	14	\$ _____	\$ _____	
81	662	6061	WK ZN PAV MRK REMOV (W)4"(DOT)	LF	40	\$ _____	\$ _____	
82	662	6080	WK ZN PAV MRK REMOV (W)(ARROW)	EA	1	\$ _____	\$ _____	
83	662	6090	WK ZN PAV MRK REMOV (W)(WORD)	EA	1	\$ _____	\$ _____	
84	666	6018	REFL PAV MRK TY I (W)6"(DOT)(100MIL)	LF	40	\$ _____	\$ _____	
85	666	6030	REFL PAV MRK TY I (W)8"(DOT)(100MIL)	LF	238	\$ _____	\$ _____	
86	666	6036	REFL PAV MRK TY I (W)8"(SLD)(100MIL)	LF	2433	\$ _____	\$ _____	
87	666	6048	REFL PAV MRK TY I (W)24"(SLD)(100MIL)	LF	174	\$ _____	\$ _____	
88	666	6054	REFL PAV MRK TY I (W)(ARROW)(100MIL)	EA	23	\$ _____	\$ _____	
89	666	6057	REFL PAV MRK TY I (W)(DBL ARROW)(100MIL)	EA	1	\$ _____	\$ _____	
90	666	6078	REFL PAV MRK TY I (W)(WORD)(100MIL)	EA	15	\$ _____	\$ _____	
91	666	6225	PAVEMENT SEALER 6"	LF	34384	\$ _____	\$ _____	
92	666	6226	PAVEMENT SEALER 8"	LF	2671	\$ _____	\$ _____	
93	666	6230	PAVEMENT SEALER 24"	LF	174	\$ _____	\$ _____	
94	666	6231	PAVEMENT SEALER (ARROW)	EA	23	\$ _____	\$ _____	
95	666	6232	PAVEMENT SEALER (WORD)	EA	15	\$ _____	\$ _____	
96	666	6234	PAVEMENT SEALER (DBL ARROW)	EA	1	\$ _____	\$ _____	

BASE BID I UNIT PRICE SCHEDULE								
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STP 2021 (088) MM								
NO.	ITEM-CODE		BRIEF DESCRIPTION OF ITEM	UNIT	QTY.	UNIT PRICE	TOTAL AMOUNT	DEPT USE ONLY
	ITEM- NO.	S.P. NO.						
97	666	6306	RE PM W/RET REQ TY I (W)6"(BRK)(100MIL)	LF	1040	\$ _____	\$ _____	
98	666	6309	RE PM W/RET REQ TY I (W)6"(SLD)(100MIL)	LF	34304	\$ _____	\$ _____	
99	666	6321	RE PM W/RET REQ TY I (Y)6"(SLD)(100MIL)	LF	100	\$ _____	\$ _____	
100	672	6010	REFL PAV MRKR TY II-C-R	LF	216	\$ _____	\$ _____	
101	677	6002	ELIM EXT PAV MRK & MRKS (6")	LF	23	\$ _____	\$ _____	
102	678	6002	PAV SURF PREP FOR MRK (6")	LF	34384	\$ _____	\$ _____	
103	678	6004	PAV SURF PREP FOR MRK (8")	LF	2671	\$ _____	\$ _____	
104	678	6008	PAV SURF PREP FOR MRK (24")	LF	174	\$ _____	\$ _____	
105	678	6009	PAV SURF PREP FOR MRK (ARROW)	EA	23	\$ _____	\$ _____	
106	678	6010	PAV SURF PREP FOR MRK (DBL ARROW)	EA	1	\$ _____	\$ _____	
107	678	6016	PAV SURF PREP FOR MRK (WORD)	EA	15	\$ _____	\$ _____	
108	678	6033	PAV SURF PREP FOR MRK (RPM)	EA	216	\$ _____	\$ _____	
109	6120	6001	DEAD END ROADWAY BARRICADE	LF	62	\$ _____	\$ _____	
			SUM TOTAL BASE BID I; Items 1-109			\$ _____		

BASE BID II UNIT PRICE SCHEDULE TXDOT CSJ: 0924-06-564								
NO.	ITEM-CODE		BRIEF DESCRIPTION OF ITEM	UNIT	QTY.	UNIT PRICE	TOTAL AMOUNT	DEPT USE ONLY
	ITEM - NO.	S.P. NO.						
1	402	6001	TRENCH EXCAVATION PROTECTION	LF	16323	\$ _____	\$ _____	
2	500	6001	MOBILIZATION	LS	1	\$ _____	\$ _____	
3	7016	6004	WATER MAIN 8-INCH	LF	160	\$ _____	\$ _____	
4	7016	6005	WATER MAIN 12-INCH	LF	240	\$ _____	\$ _____	
5	7016	6006	WATER MAIN 16-INCH	LF	80	\$ _____	\$ _____	
6	7016	6033	ADDITIONAL FITTINGS	LB	5000	\$ _____	\$ _____	
7	7016	EPW1	WATER MAIN 24-INCH	LF	15493	\$ _____	\$ _____	
8	7016	EPW2	WATER MAIN 30-INCH HDPE (DR-11)	LF	350	\$ _____	\$ _____	
9	7016	EPW3	8-INCH GATE VALVE	EA	2	\$ _____	\$ _____	
10	7016	EPW4	12-INCH GATE VALVE	EA	3	\$ _____	\$ _____	
11	7016	EPW5	16-INCH GATE VALVE	EA	1	\$ _____	\$ _____	
12	7016	EPW6	24-INCH GATE VALVE WITH MANHOLE	EA	23	\$ _____	\$ _____	
13	7016	EPW7	24-INCH BLOW OFF VALVE WITH MANHOLE	EA	9	\$ _____	\$ _____	
14	7016	EPW9	48-INCH FIBERGLASS REINFORCED PLASTIC (FRP) CASING	LF	260	\$ _____	\$ _____	
15	7016	EPWA	3-COMB. AIR RELEASE / VACUUM VALVE WITH MANHOLE	EA	8	\$ _____	\$ _____	
16	7016	EPWB	CATHODIC PROTECTION	LS	1	\$ _____	\$ _____	
17	7016	EPWC	24-INCH STEEL CASING	LF	20	\$ _____	\$ _____	
			SUM TOTAL BASE BID II; Items 1-17			\$ _____		

BASE BID III UNIT PRICE SCHEDULE TXDOT CSJ: 0924-06-564								
NO.	ITEM-CODE		BRIEF DESCRIPTION OF ITEM	UNIT	QTY.	UNIT PRICE	TOTAL AMOUNT	DEPT USE ONLY
	ITEM - NO.	S.P. NO.						
1	512	6031	PORT CTB (MOVE)(F-SHAPE)(TY 3)	LF	3022	\$ _____	\$ _____	
2	550	6001	CHAIN LINK FENCE (INSTALL) (6')	LF	466	\$ _____	\$ _____	
3	550	6003	CHAIN LINK FENCE (REMOVE)	LF	540	\$ _____	\$ _____	
			SUM TOTAL BASE BID III; Items 1-3			\$ _____		

FOR INFORMATION
PURPOSES ONLY