



Camino Real Regional Mobility Authority El Paso Streetcar Project

TECHNICAL SPECIFICATIONS - VOLUME 1 OF 2:

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- **NOTICES TO CONTRACTORS**
- **SPECIAL PROVISIONS**
- **ROAD, TRACK, CIVIL & SYSTEMS – SPECIAL TECHNICAL SPECIFICATIONS**

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EL PASO STREETCAR PROJECT MASTER TECHNICAL SPECIFICATIONS LIST

TXDOT SPECIFICATIONS, SPECIAL PROVISIONS APPLICABLE TO THIS PROJECT ARE LISTED AS FOLLOWS AND ARE LOCATED AT:

<http://www.txdot.gov/business/resources/txdot-specifications.html>

Item numbers in parentheses are TxDOT reference specifications that can also be retrieved at the above website.

**TXDOT STANDARD SPECIFICATIONS AND
STATEWIDE SPECIAL SPECIFICATIONS:**

ADOPTED BY THE TEXAS DEPARTMENT OF TRANSPORTATION NOVEMBER 1, 2014, UNLESS OTHERWISE NOTED AS "TXDOT 2004 SPEC". STANDARD SPECIFICATIONS ARE INCORPORATED INTO THE CONTRACT BY REFERENCE.

<u>ITEM NO.</u>	<u>DESCRIPTION</u>
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ITEM 110	EXCAVATION (132)
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ITEM 341	DENSE-GRADED HOT-MIX ASPHALT (300)(301)(320)(520)(585)
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 416	DRILLED SHAFT FOUNDATIONS (405)(420)(421)(423)(440)(448)
ITEM 420	CONCRETE SUBSTRUCTURES (400)(404)(421)(422)(426)(427)(440)(441)(448)
ITEM 439	BRIDGE DECK OVERLAYS
ITEM 442	METAL FOR STRUCTURES (441)(445)(446)(447)(448)
ITEM 450	RAILING (420)(421)(422)(424)(440)(441)(442)(445)(446)(448)(540)
ITEM 464	REINFORCED CONCRETE PIPE (400)(402)(403)(467)(476)
ITEM 465	JUNCTION BOXES, MANHOLES, AND INLETS (400)(420)(421)(424)(440)(471)
ITEM 476	JACKING, BORING, OR TUNNELING PIPE OR BOX (402)(403)(460)(462)(464)
ITEM 479	ADJUSTING MANHOLES AND INLETS (400)(421)(465)(471)
ITEM 481	PIPE FOR DRAINS (400)
ITEM 496	REMOVING STRUCTURES
ITEM 500	MOBILIZATION
ITEM 502	BARRICADES, SIGNS AND TRAFFIC HANDLING
ITEM 504*	FIELD OFFICE AND LABORATORY
ITEM 506	TEMPORARY EROSION, SEDIMENTATION, AND ENVIRONMENTAL CONTROLS
ITEM 529	CONCRETE CURB, GUTTER, AND COMBINED CURB AND GUTTER (360)(420)(421)(440)
ITEM 530	INTERSECTIONS, DRIVEWAYS AND TURNOUTS (247)(260)(263)(275)(276)(292)(316)(330)(334)(340)(360)(421)(440)
ITEM 531	SIDEWALKS (104)(360)(420)(421)(440)(530)
ITEM 550	CHAIN LINK FENCE (421)(445)
ITEM 618	CONDUIT (400)(476)
ITEM 620	ELECTRICAL CONDUCTORS (610)(628)
ITEM 624	GROUND BOXES (420)(421)(432)(440)(618)(620)
ITEM 636	SIGNS (643)
ITEM 644	SMALL ROADSIDE SIGN ASSEMBLIES (421)(440)(441)(442)(445)(634)(636)(643)(656)
ITEM 666	RETROREFLECTORIZED PAVEMENT MARKINGS (316)(318)(502)(662)(677)(678)
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ITEM 678	PAVEMENT SURFACE PREPARATION FOR MARKINGS (677)
ITEM 680	HIGHWAY TRAFFIC SIGNALS (610)(618)(624)(625)(627)(628)(636)(656)(682)(684)(686)(688)
ITEM 682	VEHICLE AND PEDESTRIAN SIGNAL HEADS
ITEM 684	TRAFFIC SIGNAL CABLES
ITEM 685	ROADSIDE FLASHING BEACON ASSEMBLIES (441)(442)(445)(449)(610)(620)(621)(624)(628)(656)(682)(684)(687)
ITEM 686	TRAFFIC SIGNAL POLE ASSEMBLIES (STEEL) (416)(421)(441)(442)(445)(449)
ITEM 687	PEDESTAL POLE ASSEMBLIES (445)(449)(656)(682)

ITEM 688	PEDESTRIAN DETECTORS AND VEHICLE LOOP DETECTORS (618)(624)(682)(684)
ITEM 751	LANDSCAPE MAINTENANCE (193)(730)(734)(745)
ITEM 1003 (TxDOT 2004 SPEC)	LANDSCAPE BOULDERS
ITEM 1003	TRANSPLANT PLANT MATERIAL
ITEM 1004	TREE PROTECTION
ITEM 1005	LOOSE AGGREGATE FOR GROUND COVER
ITEM 5878 (TXDOT 2004 SPEC)	WATER AND SANITARY SEWER SYSTEMS
ITEM 6002	VIDEO IMAGING VEHICLE DETECTION SYSTEM
ITEM 6027	PREPARATION OF EXISTING CONDUITS, GROUND BOXES OR MANHOLES

TXDOT STANDARD PROVISIONS:

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

SP 506-001	TEMPORARY EROSION, SEDIMENTATION, AND ENVIRONMENTAL CONTROLS
SP 506-002	TEMPORARY EROSION, SEDIMENTATION, AND ENVIRONMENTAL CONTROLS

EL PASO STREETCAR PROJECT SPECIAL PROVISIONS AND SPECIAL SPECIFICATIONS ARE LISTED AS FOLLOWS AND ARE ATTACHED IN VOLUME 1.

<u>ITEM NO.</u>	<u>DESCRIPTION</u>
ITEM EP-000-SYS	IMPORTANT NOTICE TO CONTRACTORS - SYSTEM INTEGRATION
ITEM EP-000-UTL	IMPORTANT NOTICE TO CONTRACTORS - UTILITY ADJUSTMENTS
ITEM EP-000-ADD	IMPORTANT NOTICE TO CONTRACTORS - ADD ALTERNATE ITEMS
ITEM EP-UTL COORD RELO	UTILITY COORDINATION AND RELOCATION
ITEM EP-PUBLIC INFO	PUBLIC INFORMATION SPECIFICATION
ITEM EP-TRACK	TRACK AND SPECIAL TRACKWORK
ITEM EP-TWC*	TRAIN TO WAYSIDE COMMUNICATIONS SYSTEM
ITEM EP-SYSTEMS	SYSTEMS
ITEM EP-STOPS	STREETCAR STOP FURNISHINGS
ITEM EP-TRACK REMOVAL	REMOVAL OF EXISTING STREETCAR TRACK
ITEM EP-ARM	BANNER ARM ASSEMBLY
ITEM EP-IRON FENCE	INSTALLATION OF WROUGHT IRON FENCE AND GATES AT TPSS
ITEM EP-LUMINAIRE	SPECIAL ILLUMINATION
ITEM EP-FENCE GROUND	FENCE GROUNDING
ITEM EP-GROUT	PRESSURE GROUTING BENEATH CENTER BENT FOOTINGS OF STANTON STREET BRIDGE
ITEM EP-SWP	SPECIAL GRATE INLET PROTECTION
ITEM EP-LAND	MISCELLANEOUS LANDSCAPE ELEMENTS
ITEM EP-TSP	EMERGENCY PREEMPTION TRAFFIC SIGNAL PRIORITY CONTROL SYSTEM INSTALLATION
ITEM 680-XXXX	SPECIAL PROVISION TO TXDOT STANDARD SPECIFICATION 680
ITEM 6002-XXX	SPECIAL PROVISION TO TXDOT SPECIAL SPECIFICATION 6002
ITEM EP-WWWWR	WATER AND WASTEWATER RELOCATION

EL PASO STREETCAR PROJECT SPECIAL SPECIFICATIONS (MAINTENANCE & STORAGE FACILITY) ARE LISTED AS FOLLOWS AND ARE ATTACHED IN VOLUME 2.

<u>ITEM NO.</u>	<u>DESCRIPTION</u>
ITEM EP-MSF	MAINTENANCE STORAGE FACILITY
GENERAL:	THE ABOVE-LISTED SPECIFICATION ITEMS ARE THOSE UNDER WHICH PAYMENT IS TO BE MADE (ITEMS INDICATED WITH (*) ARE CONSIDERED SUBSIDIARY TO THE PERTINENT BID ITEMS). 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 AND SPECIAL SPECIFICATIONS LISTED ABOVE, AND OTHER PROJECT SPECIFICATIONS WITHIN THIS VOLUME CONSTITUTE THE COMPLETE SPECIFICATIONS FOR THIS PROJECT.

SPECIAL PROVISION**EP 000---SYS****Important Notice to Contractors**

The Contractor's attention is directed to the fact that this project will require system integration between the various infrastructure components and the streetcar vehicle in order to achieve operations at the streetcar service opening date. The Contractor shall coordinate with the CRRMA in a reasonable manner to integrate the streetcar infrastructure and streetcar vehicles, and will include such integration efforts into its project work and schedule. The integration of the infrastructure and vehicle is a continuous process starting with construction and ending after integration testing. Interface questions shall be routed to the CRRMA for clarification.

Systems Integration testing begins once the Contractor has successfully passed and submitted the approved Acceptance Test Procedures test results by element (e.g. streetcar signals, track, traction power, OCS traffic signals, etc.) that are required by the Contract Documents. System integration testing involves testing activities between the streetcar infrastructure and the streetcar vehicle. The list of testing activities will be developed by CRRMA based on tests to be performed by the Contractor, the vehicle Contractor and the CRRMA as part of the Integration Test Plan. The integrated tests will also be used as part of the Safety Certification process that certifies that the system is ready for operation. The Contractor shall provide input and assistance to the CRRMA during the development of the Integration Test Plan.

Most contractually required tests are conducted prior to the start of integration tests, and some of these test may satisfy the requirements of an Integration Test and may also be used for that purpose. Test procedures for contractually required tests that may also be used for integration testing shall be submitted to the CRRMA for review and approval. The CRRMA will determine whether the test satisfies an integration testing requirement, and if so, the CRRMA may include it as part of the Integration Testing Plan and integration testing period.

The CRRMA is responsible for the coordination of all integration tests, and where a contractually required test is used as an integration test, the CRRMA coordinates with the responsible parties who need to perform, support and witness the test. For the contractually required tests that are included in the Integration Test Plan, the Contractor shall be responsible for performing, i.e. including equipment, test setup, test result documentation and test tear down.

Integrated testing may include, but not be limited to, the following tests:

Track

- Streetcar / Track Ride Quality
- Streetcar / Track Switch Interface

Clearance

- Streetcar / OCS Clearance / Dead Wire
- Streetcar / OCS Clearance / Live Wire

- Streetcar / Maintenance Facility

Platform Tolerances (ADA)

- Streetcar / Station Platform ADA Compliance Interface
- Streetcar / Station Clearance

Overhead Contact System (OCS)

- Streetcar pantograph/ tracking through Overlap / Section Insulator
- Streetcar pantograph / tracking under entire system OCS
- Streetcar pantograph / Maintenance Facility OCS

Compatibility with Maintenance Equipment

- Streetcar / Shop Interface Equipment

Communications

- Streetcar / Radio Communications

Signals

- Streetcar / Train to Wayside Control / Traffic Interface
- Streetcar / Signals track circuit occupancy

Traction Power

- Streetcars / Simultaneous Streetcar Start Test
- Blue Light Visibility Confirmation

Corrosion Control

- Pre and post construction stray current testing

Maintenance Facility

- Streetcar / Maintenance Facility Equipment
- Streetcar / Maintenance Facility Auxiliary Power

Contractor required support is limited to the items that are installed per the Contract Documents. The Contractor shall identify all of the tests, which are described in the Contract documents, in their construction schedule along with the inclusion of a two month period for Integration Support. The integration support time period is the CRRMA's and shall not be used for construction without CRRMA Approval.

Pre-Revenue

Pre-Revenue Operations are not a part of the Integration Test Plan and will be CRRMA responsibility.

Safety Certification

Satisfactory completion of the Systems Integration Tests also provides the basis for certifying that the systems portion of the project is capable of providing safe passenger service.

Safety certification and integration testing are managed separately by the CRRMA, but they complement and reinforce each other and therefore must be coordinated. One of the steps in Safety Certification is to identify integration tests that need to be monitored, as described in the FTA Handbook for Transit Safety and Security Certification (DOT-FTA-MA-90-5006-02-01).

SPECIAL PROVISION**EP 000---UTL****Important Notice to Contractors**

The Contractor's attention is directed to the fact that utility adjustments required for the construction of this project have not been accomplished as of Contractor Notice to Proceed. It is anticipated that all utility adjustments will be made in sufficient time to prevent any undue delay to the Contractor in his normal operations. An extension of working time will be granted, if necessary, for delays caused by interference beyond the estimated date of utility adjustments.

For the Contractor's information, the following utilities have not been adjusted. The utilities will be adjusted by their owners. The Contractor is invited to review the outstanding utility adjustments identified with the CRRMA.

Outstanding Utility Adjustments – As of June 2015

OWNER	UTILITY	ID	LOCATION (STA.)	EST. COMP DATE
El Paso Electric Company (EPECo.)	Transmission Facilities	DT-47	37+00 – 40+94	Jan-16
		DT-68	44+19	
		DT-25	23+97	
		DT-130	80+49	
		DT-137	83+77	
		DT-140...	86+39 – 103+14	
		SO-24	210+21	
		SO-31 & 34	217+07	
		SO-38...	220+45 – 235+19	
		SO-60	239+91	
		SO-68	246+45	
		SO-75	250+48	
		SO-96	265+36	
		SO-100	268+31	
		SO-104 , SO-106, SO-108	271+01 – 272+97	
		Not Listed	274+94 – 276+37	
		SO-122	278+10	

OWNER	UTILITY	ID	LOCATION (STA.)	EST. COMP DATE
El Paso Electric Company (EPECo.)		SO-146	289+26	
		SO-156	295+92	
		SO-159	299+23	
		SO-166	302+60	
		SO-181	312+98	
		SO-194	316+30 – 319+63	
		SO-198	not listed	
		SO-206	322+93	
		SO-211	326+17	
		SO-213	329+46	
		SO-214	not listed	
		SO-222	336+09	
		SO-223	not listed	
		SO-237	349+28	
	Distribution Facilities		9+90 – 17+34	Jan-16
			17+34 – 18+33 (TxDOT)	
			18+33 – 45+44	
			45+ 44 – 46+09 (TxDOT)	
			46+09 – 61+48	
			64+ 18 – 62+26 (TxDOT)	
			62+26 – 70+26	
			200+00 – 204+10	
			281+22 – 289+91	
			302+54	
			315+98	
			319+23	
			321+84 – 350+07	
			350+07 – 352+75 (TxDOT)	
			352+75 – 352+75	
	Natural Gas Facilities		9+90 – 15+20	Jan-16

OWNER	UTILITY	ID	LOCATION (STA.)	EST. COMP DATE
Texas Gas Service (TxGAS)			19+10 – 44+20	
			48+88	
			50+70 – 52+17	
			57+00 – 58+40	
			61+95 – 62+25 (TxDOT)	
			62+25 – 76+58	
			76+58 – 77+52 (TxDOT)	
			77+52 – 86+16	
			88+20	
			91+50 – 92+50	
			94+80	
			98+11	
			99+97 – 104+71	
			200+52- 203+97	
			216+92	
			220+16	
			223+97 – 224+93	
			230+00	
			243+30	
			246+59	
			256+50	
			269+78	
			276+78 – 278+03	
			280+23 – 280+32 (TxDOT)	
			280+32 – 283+07	
			297+14 – 315+81	
			329+35	
			340+62 – 350+02	
			355+83	
	Communication		24+05	Jan-16

OWNER	UTILITY	ID	LOCATION (STA.)	EST. COMP DATE
Time Warner Cable (TWC)	Facilities		26+43	
			42+31	
			44+19	
			55+36	
			61+50 – 62+26 (TxDOT)	
			63+99	
			86+58	
			88+13	
			91+36	
			94+88	
			96+68	
			98+13	
			103+25	
			204+07	
			210+21	
			230+05	
			246+50	
			256+96	
			272+97	
			278+11	
			283+33	
			295+92	
			302+60	
			312+96	
TW Telecom (TWT) -Now Level 3 Communications	Communication Facilities		Pending	Jan-16
Sprint Nextel	Communication Facilities		N/A	Coordinate During Construction
AT&T	Communication Facilities		Pending	Jan-16

OWNER	UTILITY	ID	LOCATION (STA.)	EST. COMP DATE
Level 3 Communications	Communication Facilities		9+90 – 17+40	Coordinate During Construction
			86+56 – 104+71	
			210+32	
			253+38 – 279+12	
			279+12 – 280+36 (TxDOT)	
MCI World Communication Services Inc./Verizon Wireless	Communication Facilities		34+39 – 35+01	Coordinate During Construction
			40+68 – 45+40	
			45+40 + 46+10 (TxDOT)	
			46+10 – 52+29	
			53+25	
			55+25	
			61+56 – 62+25 (TxDOT)	
			62+25 – 66+58	
			94+80	
			210+42	
			216+82 – 279+17	
			279+17 – 279+70 (TxDOT)	
			306+18 – 329+50	
Q-West Communications International/Century Link	Communication Facilities		N/A	Coordinate During Construction
Transtelco Inc.	Communication Facilities		N/A	Coordinate During Construction
Valley Telecommunications Group	Communication Facilities		48+87	Coordinate During Construction
			210+19 – 260+91	
			262+42 – 279+19	
Light Link Network	Communication Facilities		N/A	Coordinate During Construction

SPECIAL PROVISION**EP 000---ADD****ADD ALTERNATE ITEMS**

The Contractor's attention is directed to the information presented below regarding additive alternate infrastructure items to be considered by the CRRMA for this Streetcar project. Add alternates are additional items of work that may be awarded as part of the contract if the bids come within the budget specified in the contract.

Additive Alternate items below are listed in no particular order. All items shall be furnished and installed as shown in construction plans and details or as designated by the project Owner (or Owner's representative)

1. Furnish and installing transit shelters at designated stop locations. The item will be measured and paid for as indicated elsewhere in the following project documents:
 - Shelters EP-STOPS
2. Furnish and installing waste receptacles at stop locations as designated by the Owner or Owner's Representative. The item will be measured and paid for as indicated elsewhere in the following project documents:
 - Waste Receptacles EP-STOPS
3. Furnish and installation of Sun Metro information holders at stop locations as shown in construction plans and details and details. The item will be measured and paid for as indicated elsewhere in the following project documents:
 - Transportation Information Holder EP-STOPS
4. Furnish and installation of the Blockout area and Sun Metro Logo Panel at stop locations as show in construction plans and details. The item will be measured and paid for as indicated elsewhere in the following project documents:
 - Sun Metro Logo Panel EP-STOPS
5. Furnish and installation of irrigation systems at stop locations as shown in construction plans and details. The item will be measured and paid for as indicated elsewhere in the following project documents:
 - Irrigation System (location A) TxDOT specification 170 6006
 - Irrigation System (location B) TxDOT specification 170 6007
 - Water Meter EP-LAND

6. Furnish and installation of tree grates at stop locations as shown in construction plans and details or as designated by the Owner. The item will be measured and paid for as indicated elsewhere in the following project documents:
 - Grates EP-LAND
7. Furnish and installation of trees at stop locations as shown in construction plans and details. The item will be measured and paid for as indicated elsewhere in the following project documents:
 - Plant Material (30 gallon Tree) TxDOT specification 192 6024
8. Furnish and installation of vegetation barriers at stop locations as shown in construction plans and details. The item will be measured and paid for as indicated elsewhere in the following project documents:
 - Vegetation Barrier TxDOT specification 192
9. Furnish and installation of aggregate for ground cover at stop locations as shown in construction plans and details. The item will be measured and paid for as indicated elsewhere in the following project documents:
 - Loose Aggregate for Ground Cover TxDOT specification 1005 6001
10. Maintenance of trees and vegetation planted in accordance with this contract until final acceptance of the project. The item will be measured and paid for as indicated elsewhere in the following project documents:
 - Maintenance TxDOT specification 192
11. Performance of and oversight over public information duties connected with construction activities for the El Paso Streetcar Project. The item will be measured and paid for as indicated elsewhere in the following project documents:
 - Public Information EP-PUBLIC INFORMATION
12. Coordination with the project Owner, Owner's Representative, and utility Point of Contact (POC) regarding the adjustment and relocation work of any known and unknown utility infrastructure relocations required within the project limits of construction for subsurface and above ground utilities. The item will be measured and paid for as indicated elsewhere in the following project documents:
 - Utility Coordination EP-UTILITY COORDINATION
13. Furnish and installation of "City of El Paso Style Decorative Light Poles" at stop locations as shown in construction plans and details. The item will be measured and paid for as indicated elsewhere in the following project documents:
 - Decorative Light Poles (Non-OCS) EP-LUMINAIRE
14. Furnish and installation of standard, LED illumination fixtures on Joint-Use OCS poles at locations indicated in construction plans and details. The item will be measured and paid for as indicated elsewhere in the following project documents:

- Joint Use OCS Poles (Standard LED) EP-LUMINAIRE

15. Furnish and installation of LED illumination fixtures compliant with the City of El Paso’s “Dark Sky” ordinance, on Joint-Use OCS poles at locations indicated in construction plans and details. The item will be measured and paid for as indicated elsewhere in the following project documents:

- Joint Use OCS Poles (Dark Sky Compliant) EP-LUMINAIRE

The Proposer should note that Additive Alternate items of work may be awarded in lieu of base bid items, if the bids come within the budget specified in the contract. Unless otherwise indicated, the quantity of Incremental Alternative items will be equal to the quantity of Base Bid item to be replaced. When completing the Unit Price Schedule for Add Alternate items in Form G, the Proposer shall enter a unit cost for the Additive Alternative item equal to the unit price differential of the Additive Alternative item minus the Base Bid item(s) being replaced.

Construction items identified below may be installed in place of Base Bid I items if the construction bids come within the budget specified in the contract:

16. Furnishing and installation of Ornamental (Decorative) style Overhead Contact System (OCS) Poles in lieu of standard tapered style OCS poles as shown in construction plans and details. Four project segments have been identified for additional installation of Ornamental OCS poles: 1) Kansas Street, from Paisano Drive to Father Rahm Avenue, 2) Father Rahm Avenue, from Kansas Street to Santa Fe Street, 3) Kansas Street, from Franklin Street to Paisano Drive, and 4) Oregon Street, from Glory Road to Franklin Street. The item will be paid for as indicated elsewhere in the following project specification documents:

- Ornamental OCS Poles EP-SYSTEMS

17. Furnishing and installation of a wrought iron perimeter fence at Traction Power Substation (TPSS) locations as identified in construction the plans in lieu of Base Bid TxDOT Specification Item 550 – Chain Link Fence (Install) (6’). The item will be paid for as indicated elsewhere in the following project specification documents:

- Wrought Iron Fence EP – IRON Fence

SPECIAL SPECIFICATION**EP-UTL COORD RELO****Utility Coordination & Relocation****1. Description.**

- A. This section describes the coordination and relocation work of any known and unknown utility infrastructure relocations required within the project limits of construction for subsurface and above ground utilities.
- B. This specification does not relieve the Prime Contractor (Contractor) of his responsibility to contact the utility clearance services prior to excavation.
- C. The Contractor maintains overall responsibility of the total project, including the performance and coordination of all sub-contractors for any utility infrastructure relocations and/or adjustments required to complete the project as intended by the contract documents. In addition to the Contractor's responsibility, this specification does not relieve any sub-contractors of their responsibility to contact the utility clearance services prior to excavation, which includes surface ground spots of buried utilities and utility exposures through the use of excavation, as required by the contract.
- D. The procedures presented in this Section include guidelines for the Contractor to coordinate with the Owner, Owner's representative, and utility Point of Contact (POC). The List of Utility POCs is located on the Drawings, Sheet Codes U100 through U133. This list is not all inclusive and it's the responsibility of the Contractor to determine other POC's as necessary during the course of the project, including utility infrastructure that may be exposed during construction and is not indicated in the drawings.
- E. The Contractor shall set up and coordinate a "Utility Coordination Meeting" in conjunction with the project Kick Off meeting with all utility POCs to discuss the project and scheduling requirements, a minimum of thirty (30) days prior to the beginning of major construction activities.
- F. The Contractor shall assign an individual (Utility Coordinator) within its organization to oversee and coordinate all utility relocations and/or adjustments. The Utility Coordinator shall have minimum of 4 years of similar urban roadway and urban utility construction experience over the last 5 years. The individual performing the Utility Coordinator role may perform multiple roles on the project. Provide the contact information for the Contractor's Utility Coordinator to the attendees of the Utility Coordination Meeting. The Utility Coordinator's resume shall be submitted and approved by the Owner prior to the beginning of construction.
- G. The Contractor shall send all utility POCs an approved updated schedule as directed by the Contract documents and submittal process.
- H. Any amendment to the project schedule shall be sent to the utility POCs once approval is received from the Owner.
- I. The Contractor shall notify each designated utility POC of operations in the vicinity of their respective utility a minimum of forty-eight (48) hours prior to work occurring in that area.
- J. Locate the infrastructure and appurtenances described in the Contract. Notify the Engineer if the infrastructure described in the Contract cannot be found.

- K. Contractor shall be aware that utility relocations and or adjustments may impede the Contractor's construction progress in certain specific locations. Contractor shall be prepared to adjust its work activities until the utility work is completed. Any work stoppage at a utility conflict location shall not impede construction progress. If construction impediment is imminent, the Contractor shall coordinate with the Owner and provide an adjusted schedule for approval.
- L. All relocated utilities shall be installed per the depth below grade or the height above grade for that specific utility type, according to the standards of the City of El Paso and those of each utility company.
- M. Contractor shall coordinate with El Paso Electric Company (EPEC) POC for all locations where EPEC relocations and or adjustments are to be completed by EPEC that also include customer service connections. Contractor shall use its electrical sub-contractor and coordinate with EPEC where the Contractor's electrical sub-contractor shall complete all customer service connections resulting from EPEC's relocations and or adjustments of its infrastructure.
- N. The Utility Coordinator shall keep copies of all TXDOT permits on site at all times. Copies of the permits will be delivered to the Contractor during the pre-construction meeting.
- O. Consult the Drawings, Sheet Codes U134 through U138 for a list of known utility conflicts and known designations. Four different scenarios for resolving the conflicts are listed below:
 - a. Utilities adjusted prior to infrastructure Contractor NTP
 - i. Meet with the utility POCs to verify that the required adjustments have been made. Coordinate construction activities adjacent to their respective utilities. Determine if the utility requires specific qualifications and/or an on-site representative for specific quality assurance.
 - ii. Proceed with construction activities with notification to the utility company and include adequate specified oversight and safety measures to protect against any damage and or disturbance of the utility infrastructure during construction activities, as well as measures to protect the Contractor's personnel.
 - b. Utilities adjusted after NTP, but before construction activity begins at that specific location.
 - i. Meet with the utility POCs to coordinate construction activities adjacent to their respective utilities. Coordination includes schedule and scope of the Contractor's work. Determine if the utility requires specific qualifications and/or an on-site representative for specific quality assurance.
 - ii. Verify if the utility in question is active, inactive, or abandoned in place.
 - iii. Proceed with construction activities with notification to the utility and proper specified oversight.
 - c. Utilities to be adjusted by the Utility owner during infrastructure construction at that specific location.
 - i. Meet with the utility POCs to coordinate construction activities adjacent to respective utilities that are still in conflict with the project. Coordination includes schedule and scope of the Contractor's work. Determine if the utility requires specific qualifications and/or an on-site representative for specific quality assurance. Verify if the utility in question is active, inactive, or abandoned in place.
 - ii. Proceed with construction activities with notification of the utility and proper specified oversight.
 - d. Unknown Utilities discovered after NTP that require relocation, adjustment, and/or protection.
 - i. Verify if the utility in question is active, inactive, or abandoned in place.

- ii. Contractor to adjust its work in the vicinity of and adjacent to the location of the unknown utility to avoid any work stoppage. Immediately contact Owner and the utility POCs to determine the nature, utility ownership and function of the unknown utility. The Contractor shall protect the utility. Any damage inflicted by the Contractor shall be repaired by the Contractor.
- iii. Meet with the utility POCs to coordinate construction activities adjacent to their respective utilities. Determine if the utility requires specific qualifications and/or an on-site representative for specific quality assurance.
- iv. Where an abandoned underground piped utility is found, it shall be cut and plugged with 6 inches (150 mm) of concrete (in accordance with Specification Item 420, "Concrete Substructures") brick and mortar (in accordance with Specification Item 465, "Junction Boxes, Manholes, and Inlets") or a precast stopper grouted in place. The Contractor shall provide all means, methods and equipment to complete cutting and plugging, including trash pump(s) for dewatering of the pipeline during cutting operations. Contractor shall coordinate with applicable utility company to confirm such lines are fully abandoned prior to cutting.
- v. Proceed with construction activities with approval of the utility and proper specified oversight.

2. Materials.

- a. None included in this section

- 3. Measurement.** The work performed by the Contractor's Utility Coordinator in this specification will be measured on a lump sum basis.
- 4. Payment.** The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the lump sum price bid for "Utility Coordination".

SPECIAL SPECIFICATION**EP-PUBLIC INFO****Public Information Specification****1. Project Description**

The El Paso Streetcar Project links the International Bridges, downtown, the Cincinnati Entertainment District and University of Texas at El Paso. The project complements several initiatives in El Paso including Sun Metro Brio, “CBD” streetscape improvements, and Southwest University Park. Construction would consist of approximately 4.8 miles of track, 27 streetcar stops, related street improvements, and a vehicle maintenance & storage facility near the existing Sun Metro Downtown Transfer Center, plus the refurbishment of President’s Conference Committee (PCC) streetcars.

2. Scope of Work/Work Plan--Public Information Support

The Public Information Consultant (PIC) will perform public information duties connected with construction activities for the El Paso Streetcar Project during the project, a time period anticipated to be 30 months. The level of effort required to complete this job is estimated to average 50 hours per month.

The primary contacts for the PIC will be the Contractor and the Owner. CRRMA is providing oversight over all public information/involvement plans and activities to facilitate communication and ensure smooth functioning of those activities on the project. CRRMA will approve all public information/involvement activities and materials with input from Sun Metro.

The PIC will begin work when the Contractor receives Notice to Proceed. At that time, the PIC will begin contacting corridor businesses and residents, and other key project stakeholders to begin the timely distribution of project information.

The Contractor shall submit the qualifications to the Owner for approval prior to the PIC commencing work.

3. PIC Qualifications

Minimum requirements:

- Shall be bilingual (English and Spanish)
- Shall have a thorough understanding of basic public involvement/public information concepts and practices, as well as extensive experience using these practices in successful public involvement/outreach campaigns and activities
- Shall have experience working on government projects in a public involvement/outreach role.

- Shall have experience working with construction contractors and an understanding of the construction process
- Shall have knowledge of local (El Paso) community issues and concerns regarding streetcar project (understanding of those in favor of project as well as those opposed).

Briefly outline your experience in these areas and list contact information for at least three professional references who can verify the listed experience.

Scope of Work Activities:

- Prepare Public Information Plan Submittal for review by Owner.
- Coordinate with the Contractor and Owner to stay up-to-date on construction activities, schedules and Maintenance of Traffic plans.
 - Attend, at minimum, every other weekly construction meeting to identify and resolve stakeholder issues. Coordinate daily during construction with the Contractor and/or Owner to stay informed of construction activities.
- Meet with residents and businesses along corridor to discuss construction activities, gather comments and address concerns. Initiate and maintain communications with key stakeholders for the duration of the project, through personal visits, by telephone, or by email.
- Develop and maintain comprehensive mailing and contact lists for use in distributing project materials and informing stakeholders.
- Provide construction updates
 - Work with the Contractor to compile construction update reports outlining scheduled construction activities at least one week in advance and distributed each week to the Owner and others identified during the course of the project.
 - Provide regular updates of construction activities that affect traffic or access to residences and/or businesses to directly impacted stakeholders who request notification, and other stakeholders identified by CRRMA or the Contractor.
 - Compile and package project-related information for distribution to news media through the Owner.
- Organize and attend public activities and meetings.
 - Schedule, organize, advertise, and facilitate a “meet the contractor” open house in coordination with Owner and the Contractor
 - Organize and facilitate a construction-safety-related activity or assembly with nearby schools and pedestrian/bicycle advocacy organizations to highlight any safety concerns and inform individuals about construction.
- Attend neighborhood, community, local government and other meetings to provide project information and record stakeholder comments and concerns.

- Prepare a construction information flier to be distributed to residents and businesses along the corridor to inform them of planned construction activities and the schedule for those activities.
- Prepare, produce and distribute at least two newsletters to inform project stakeholders during, and at the end of construction. The newsletters will describe construction activities and work schedules, and include additional information that will improve the construction experience for stakeholders.
- Develop/update content for the project website that includes project background, information about upcoming construction activities, frequently asked questions, and contact information.
- Provide a dedicated contact phone with a message machine for stakeholder contacts during the course of the project. Follow up on all stakeholder concerns within 24 hours.
- Provide project progress reports on public involvement/public information activities.
 - Compile and submit a detailed report with each invoice to the Owner that includes at minimum:
 - An overview of public information and public involvement activities
 - A record of all stakeholder contacts
 - A record of all stakeholder questions and concerns
 - A record of all responses and resolutions to stakeholder questions and concerns
- Compile and distribute a Summary Report at the conclusion of construction to the Owner that includes at minimum:
 - An overview of public information and public involvement activities from the beginning to the end of the project.
 - An analysis of what worked well and what did not work well concerning public information and public involvement during the project.
 - A database of project contacts including the names, addresses, phone numbers and email addresses of all project stakeholders.
- Assume other public information and public involvement duties as needed and requested by CRRMA and the Construction Contractor.

All materials prepared for public distribution must be approved by the Owner and the Contractor before distribution. Materials must be prepared and presented in Spanish and English (use of simultaneous translation as applicable).

4. Materials.

- a. None included in this section

5. **Measurement.** The work performed by the Contractor's PIC in this specification will be measured on a lump sum basis.
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 lump sum price bid for "Public Information".

SPECIAL SPECIFICATION

EP-TRACK

Track & Special Trackwork

1. **Description.** Construct the track and special trackwork for the El Paso Streetcar Project in El Paso, Texas, as shown on the plans and the attached specifications.
2. **Materials.** All materials furnished and all construction methods utilized shall be in accordance with the plans, details, and attached specifications.
3. **Measurement.** This Item will be measured as indicated in the attached specifications.
4. **Payment.** The work performed and materials furnished in accordance with the attached specifications.

Attached Specifications

- 34 11 13 Girder Rail and Block Rail
- 34 11 16 Welded Track Rails
- 34 11 23.31 Special Trackwork
- 34 11 23.33 Embedded Special Trackwork
- 34 11 23.50 Elastomeric Encapsulation
- 34 11 29.10 Embedded Trackwork
- 34 11 93.10 Bolted Joint and Insulated Rail Joint
- 34 11 93.20 Track Electrical Testing

URS Corporation
TBPE Firm Registration No. F-3162



Section 34 11 13

GIRDER RAIL AND BLOCK RAIL

Section 34 11 13, which is not a Standard Specification, is included in this Project by Special Provision.

PART 1 - GENERAL

1.1 Summary

- A. This section specifies the furnishing of girder rail and block rail, tangent and precurved, and transition rail for paved track installation. Supplier shall provide transportation to deliver, unload and place into storage all rail.
- B. Girder rail procured under this contract will subsequently be installed in concrete or asphalt paved streets on the El Paso Streetcar system.
- C. Block rail procured under this contract will subsequently be installed on bridge deck and in concrete or asphalt paved streets on the El Paso streetcar System.
- D. Transition Rails 51R1/Block Rail.
- E. Spare Girder rail and Block Rail material

1.2 References

- A. The following Codes, Regulations, Reference Standards and Specifications in effect on the bid due date shall apply to work included in this section:
 - 1. EN 14811: European Standard "Railway Applications – Track – Special Purpose rails - Grooved".

1.3 Submittals

- A. Submit results for testing included in EN 14811. At a minimum, these shall include test results for chemical composition, tensile strength and Brinell hardness. The electric conductivity of the rail shall also be submitted to verify the maximum allowable direct current resistance has not been exceeded.
- B. Submit shop drawings of precurved rail units. Drawings shall show layout of rails, curve data, rail lengths, weld gaps between rails and methods used to clearly identify and label all individual rail lengths in each precurved rail unit.
- C. If the contractor elects to Pre-Bend rails at a facility located in the US (domestic facility), then the name, location and pre-bending equipment proposed for use must be submitted to the owner for approval prior to fabrication of any precurved rails.

PART 2 - PRODUCTS

2.1 Materials to be furnished by the contractor:

- A. All rails shall be new girder rail or block rail manufactured in accordance with EN 14811 except as noted below for block rail.
 - 1. Block rail shall be marked on the flange in the following format: "XX Y ZZZZZ"
 - a. XX = mill designation
 - b. Y = rail grade (S for standard/R220G1 and P for premium/R260)
 - c. ZZZZZ = manufacturer's code designating time of manufacture and heat#
 - 2. Block rail stamped characters shall be legible and no smaller than 3/8"
 - 3. The following adjustments to residual elements will be allowed for block rail:
 - a. Molybdenum 0.050% max
 - b. Aluminum 0.010% max
 - c. Copper 0.40% max
 - d. Copper +10*Tin 0.65% max
 - e. The sum of chromium + molybdenum + nickel + copper + vanadium will be waived Tensile test diameter can be 12.5mm and can be located on the field side corner of the running head
- B. All rails shall be supplied with blind ends for welding.
- C. Girder rail shall be Standard Section 51R1. Refer to attached Figures 1 for dimensions and tolerances. Girder rail shall be furnished in grades R220G1 and R290GHT per EN 14811. Furnish 51R1 girder rail of grade R220G1 for installation on most tracks running rails except grade R290GHT shall be furnished for following track rails;
 - 1. Girder rail on Station Stops to begin 50 feet before and 50ft after platform edge. For location of Station Stops refer to Contract Drawings.
 - 2. Precurved Girder rails on sharp horizontal curve radius (400 feet or less). Precurving to begin at the 10ft tangent extension before and after PC-PT or TS-ST. Refer to attached Figures 3 for girder rail typical precurving details. For location of curved tracks with rails required to be precurved refer to Contract Drawings.
 - 3. Girder rail to be installed on steep slope tracks greater than 5% gradient. For location of tracks with steep slope greater than 5% refer to Contract Drawings.
 - 4. Transition Rail 51R1/Block-Rail Transition rail. For location of transition rail installation refer to Contract Drawings.
- D. Block rail shall be Section 112TRAM or approved equal. Refer to attached Figures 2 for dimensions and tolerances. Block rail shall be furnished in grade R290GHT per EN 14811. For location of tracks with block installation refer to Contract Drawings.

- E. The nominal rail length shall be 18 meters (59 feet) for girder rail, and a minimum of 11.89 meters (39 feet, with a tolerance of $\pm 7/16''$) for block rail, except for precurved rails. Precurved rail lengths can be shorter than 18 meters if necessary for fabrication of the precurved rail units. Refer to attached Figures 3 for girder rail typical precurving details. Lengths of precurved rails shall be shown on shop drawings and approved by the owner's representative prior to fabrication.
- F. Rail ends shall be cut square to the vertical axis of the rail. A tolerance of 1mm out of square from the base to the head will be permitted.
- G. All rails shall have a maximum allowable direct current (DC) resistance of not more than 10.5×10^{-6} ohms per foot.
- H. Precurved girder rails (block rails will not be precurved horizontally) shall be uniformly curved to match the required geometry. Tolerances for rail bending must ensure that bent rails can be laid out on a flat concrete surface or on vertical curves sloping concrete surface at the required geometry without requiring bracing or other measures to hold the required geometry. Any rail twisting that will result in more than a $1/16''$ gap under any portion of the rail base will be cause for rejecting the curved rail.
- I. If the contractor elects to Pre-Bend rails at a domestic facility, then the contractor must ensure the facility uses rollers to bend the rails (not a three-point press) unless otherwise approved by the owner. Any rails damaged during the pre-bending process shall be replaced by the contractor and the contractor shall bear all the costs of replacing the damaged rails.
- J. Spare materials to be provided by the Contractor in addition to materials to be furnished and installed in this section are;
 - 1. Girder rail R220G1 x 18m = 10pcs
 - 2. Girder rail R290GHT x 18m = 8 pcs
 - 3. Block rail R290GHT x 11.28m = 4 pcs
 - 4. Transition Rail 51R1/112Tram = 2 pairs

2.2 Packaging and Shipping

- A. All girder rail and block rail shall be protected from salt water. This protection shall not be accomplished by painting the rail.
- B. Precurved rail units shall be clearly labeled as shown on approved shop drawings. Labels must include the precurved unit number and must clearly indicate where individual rails are located within the unit. Loose tags or other easily removable labels are not acceptable.
- C. Contractor will be responsible for furnishing, shipping and delivery of the tangent girder rails material to be precurved to the location of the Contractor's (Subcontractor) precurving Shop.
- D. Material shall be shipped to El Paso Texas, unloaded and transported to a storage site within one mile of the project as designated by the purchaser. The project is located in El Paso, Texas.

PART 3 - EXECUTION (Not Used)

PART 4 - MEASUREMENT

4.1 General

- A. No separate measurement will be made for items in this section. Furnishing, shipping, hauling, unloading, delivery to site and installing of girder rail, block rail, transition rails, precurved rail and spare rail materials to be provided under this section shall be incidental to Embedded Trackwork TF (track feet) in Section 34 11 29.10.

PART 5 - Payment

5.1 General

- A. No separate payment will be made for items in this section. Hauling, unloading, furnishing and installing girder rail, block rail and precurved rail shall be incidental to Embedded Trackwork TF (track feet) in Section 34 11 29.10.

END OF SECTION

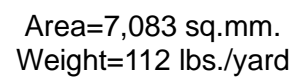
Technical drawing of a mechanical part, showing dimensions and labels. The drawing includes a top view and a side view. Key dimensions and labels are as follows:

- Top View Dimensions:**
 - Overall width: 113
 - Overall height: 130
 - Top horizontal segments: 55.83 and 42.52
 - Top vertical segment: 15.08
 - Top horizontal segment (right): 12.67
 - Top vertical segment (right): 6
 - Top horizontal segment (right): 4.7
 - Top vertical segment (right): 69.05
 - Top horizontal segment (right): 15
 - Top vertical segment (right): 12
 - Top horizontal segment (right): 25.22
 - Top vertical segment (right): 26.69
 - Top horizontal segment (right): 110
 - Top vertical segment (right): 110
 - Top horizontal segment (right): 6.2
 - Top vertical segment (right): 9.5
- Side View Dimensions:**
 - Overall height: 65.05
 - Overall width: 150
 - Side horizontal segment: 12
 - Side vertical segment: 25.22
 - Side horizontal segment: 26.69
 - Side vertical segment: 110
 - Side horizontal segment: 110
 - Side vertical segment: 6.2
 - Side horizontal segment: 9.5
- Labels and Notes:**
 - Labels: A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, Z, AA, AB, AC, AD, AE, AF, AG, AH, AI, AJ, AK, AL, AM, AN, AO, AP, AQ, AR, AS, AT, AU, AV, AW, AX, AY, AZ, BA, BB, BC, BD, BE, BF, BG, BH, BI, BJ, BK, BL, BM, BN, BO, BP, BQ, BR, BS, BT, BU, BV, BW, BX, BY, BZ, CA, CB, CC, CD, CE, CF, CG, CH, CI, CJ, CK, CL, CM, CN, CO, CP, CQ, CR, CS, CT, CU, CV, CW, CX, CY, CZ, DA, DB, DC, DD, DE, DF, DG, DH, DI, DJ, DK, DL, DM, DN, DO, DP, DQ, DR, DS, DT, DU, DV, DW, DX, DY, DZ, EA, EB, EC, ED, EE, EF, EG, EH, EI, EJ, EK, EL, EM, EN, EO, EP, EQ, ER, ES, ET, EU, EV, EW, EX, EY, EZ, FA, FB, FC, FD, FE, FF, FG, FH, FI, FJ, FK, FL, FM, FN, FO, FP, FQ, FR, FS, FT, FU, FV, FW, FX, FY, FZ, GA, GB, GC, GD, GE, GF, GG, GH, GI, GJ, GK, GL, GM, GN, GO, GP, GQ, GR, GS, GT, GU, GV, GW, GX, GY, GZ, HA, HB, HC, HD, HE, HF, HG, HH, HI, HJ, HK, HL, HM, HN, HO, HP, HQ, HR, HS, HT, HU, HV, HW, HX, HY, HZ, IA, IB, IC, ID, IE, IF, IG, IH, II, IJ, IK, IL, IM, IN, IO, IP, IQ, IR, IS, IT, IU, IV, IW, IX, IY, IZ, JA, JB, JC, JD, JE, JF, JG, JH, JI, JJ, JK, JL, JM, JN, JO, JP, JQ, JR, JS, JT, JU, JV, JW, JX, JY, JZ, KA, KB, KC, KD, KE, KF, KG, KH, KI, KJ, KK, KL, KM, KN, KO, KP, KQ, KR, KS, KT, KU, KV, KW, KX, KY, KZ, LA, LB, LC, LD, LE, LF, LG, LH, LI, LJ, LK, LL, LM, LN, LO, LP, LQ, LR, LS, LT, LU, LV, LW, LX, LY, LZ, MA, MB, MC, MD, ME, MF, MG, MH, MI, MJ, MK, ML, MM, MN, MO, MP, MQ, MR, MS, MT, MU, MV, MW, MX, MY, MZ, NA, NB, NC, ND, NE, NF, NG, NH, NI, NJ, NK, NL, NM, NN, NO, NP, NQ, NR, NS, NT, NU, NV, NW, NX, NY, NZ, OA, OB, OC, OD, OE, OF, OG, OH, OI, OJ, OK, OL, OM, ON, OO, OP, OQ, OR, OS, OT, OU, OV, OW, OX, OY, OZ, PA, PB, PC, PD, PE, PF, PG, PH, PI, PJ, PK, PL, PM, PN, PO, PP, PQ, PR, PS, PT, PU, PV, PW, PX, PY, PZ, QA, QB, QC, QD, QE, QF, QG, QH, QI, QJ, QK, QL, QM, QN, QO, QP, QQ, QR, QS, QT, QU, QV, QW, QX, QY, QZ, RA, RB, RC, RD, RE, RF, RG, RH, RI, RJ, RK, RL, RM, RN, RO, RP, RQ, RR, RS, RT, RU, RV, RW, RX, RY, RZ, SA, SB, SC, SD, SE, SF, SG, SH, SI, SJ, SK, SL, SM, SN, SO, SP, SQ, SR, SS, ST, SU, SV, SW, SX, SY, SZ, TA, TB, TC, TD, TE, TF, TG, TH, TI, TJ, TK, TL, TM, TN, TO, TP, TQ, TR, TS, TT, TU, TV, TW, TX, TY, TZ, UA, UB, UC, UD, UE, UF, UG, UH, UI, UJ, UK, UL, UM, UN, UO, UP, UQ, UR, US, UT, UU, UV, UW, UX, UY, UZ, VA, VB, VC, VD, VE, VF, VG, VH, VI, VJ, VK, VL, VM, VN, VO, VP, VQ, VR, VS, VT, VU, VV, VW, VX, VY, VZ, WA, WB, WC, WD, WE, WF, WG, WH, WI, WJ, WK, WL, WM, WN, WO, WP, WQ, WR, WS, WT, WU, WV, WW, WX, WY, WZ, XA, XB, XC, XD, XE, XF, XG, XH, XI, XJ, XK, XL, XM, XN, XO, XP, XQ, XR, XS, XT, XU, XV, XW, XX, XY, XZ, YA, YB, YC, YD, YE, YF, YG, YH, YI, YJ, YK, YL, YM, YN, YO, YP, YQ, YR, YS, YT, YU, YV, YW, YX, YY, YZ, ZA, ZB, ZC, ZD, ZE, ZF, ZG, ZH, ZI, ZJ, ZK, ZL, ZM, ZN, ZO, ZP, ZQ, ZR, ZS, ZT, ZU, ZV, ZW, ZX, ZY, ZZ.

H	AB	BC	CD
9	54,49	44,52	13,57
10	54,97	43,88	14,06
14	56,00	42,17	14,39

Cross-sectional area: 65,44 cm²
 Linear mass: 51,37 kg/m
 Moment of inertia I_{xx} : 1 288,7 cm⁴
 Moment of inertia I_{yy} : 695,6 cm⁴
 Section modulus W_x : 198,1 cm³
 Section modulus W_{xh} : 198,4 cm³
 Section modulus W_{yh} : 85,7 cm³
 Section modulus W_{ygh} : 101,1 cm³

Figure A.2 — Grooved rail profile 51R1



V1-26

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34 11 16
Welded Track Rails

PART 1 - GENERAL

1.1 Summary

- A. This Section specifies the furnishing, installation and testing of rail welds to connect rails as shown on the Contract Drawings and as specified herein. The contractor must weld rails into continuous welded rail (CWR) using the flash-butt welding method unless otherwise approved by the owner. The Contractor may elect to use thermite weld kits or utilize a mobile electric flash-butt welding plant to connect CWR strings in the field.

1.2 Related Sections

- A. 34 11 29.10 - Embedded Trackwork
- B. 34 11 23.33- Embedded Special Trackwork

1.3 References

- A. AREMA - Manual for Railway Engineering, Vol. I, Chapter 4, Part 3 - Specifications, "Thermite Welding - Rail Joints" and "Specification for the Quality Assurance of Elastic Flash-Butt Welding of Rail
- B. ASTM E 10 - Test Method for Brinell Hardness of Metallic Materials
- C. ASTM E 164 - Practice for Ultrasonic Contact Examination of Weldments
- D. ASTM E 709 - Practice for Magnetic Particle Examination
- E. ASNT CP-189 - Standard for Qualification and Certification of Nondestructive Testing Personnel

1.4 Submittals

- A. Submittals shall be made in accordance with the general requirements, and as described herein. The Contractor shall submit the following:
 - 1. Thermite and/or mobile electric-flash butt welding procedure Specification.
 - 2. Procedure qualification test results.
 - 3. Report on UT and magnetic particle inspection of production field welds.
 - 4. A daily report of field welding records.

5. Identification of the testing service, their testing program and procedures, and a copy of their agreement.

PART 2 - PRODUCTS

2.1 Materials

A. Materials to be Furnished by the Contractor:

1. Welding Kit - The Contractor shall select and furnish a welding kit that conforms to the requirements of AREMA "Thermite Welding - Rail Joints" except as modified herein. The thermite welding kit material manufacturer shall certify the thermite powder portions are in compliance with the referenced requirements. Appropriate kits shall be supplied for welding the various grades of rail together.

PART 3 - EXECUTION

3.1 Construction

- A. Welding Procedures - All welding procedures and methods shall conform to the requirements of AREMA "Thermite Welding - Rail Joints" and/or "Specification for the Quality Assurance of Electric Flash-Butt Welding of Rail" except as modified herein.
- B. Procedure Specification - The Contractor shall prepare a detailed procedure Specification for the owner's review and approval covering step-by-step procedures to be employed in making field thermite and/or mobile electric-flash butt welds. A complete description of each of the following items and any other essential characteristics shall be included in the procedure Specification.
 1. Manufacturer's trade name for welding process.
 2. Method used for cutting and cleaning of rail ends. Flame cutting will not be allowed.
 3. Minimum and maximum gap between rail ends.
 4. Method and equipment used for maintaining rail gap and alignment during welding.
 5. Method used for preheating rail ends including time and temperature.
 6. Tapping procedure including minimum time required to cool weld under the mold insulation.
 7. Method used for removing gates and risers and finishing weld suitable for radiographic inspection, including a description of special tools and equipment.
 8. The manufacturer's recommended procedure for welding girder rail if different from requirements for standard rail.
 9. Quality control procedures.

C. Qualification of Field Welding Procedure

1. The Contractor shall qualify the procedure Specification described above by preparing and testing; one (1) qualification test weld for 51R1, one (1) qualification test weld for block rail and three (3) qualification test welds for each rail type prior to beginning production welding. The qualification test welds shall be prepared by the contracting welding crews in conformance with the procedures listed in the Section on short lengths of rail out of track, and in the presence of the Engineer.
 2. The qualification test welds shall be inspected and tested by the testing service in accordance with the following requirements:
 - a. Weld Quality
 - b. Hardness
 - c. Weld Inspection Testing
 - d. Weld Inspection
 - e. Ultrasonic Weld Testing
 - f. Magnetic Particle Testing
 3. The qualification test weld shall be sectioned longitudinally through the middle of the rail and chemically etched. The etch shall show a clean definition of the weld metal and heat affected zone of the weld joint. The testing service shall examine the etched sections for conformance with the weld quality requirements of this Section. One of the etched sections and the report of the testing service shall be submitted to the Engineer.
 4. The procedure Specification will be considered qualified if the weld kit and/or the mobile electric-flash butt welding plant and all tests and inspections meet or exceed the acceptance requirements. If any test or inspection is failed, the Contractor shall submit and qualify a revised procedure Specification in accordance with the requirements herein.
 5. Production field welding shall not begin until a Procedure Specification is qualified in accordance with the requirements herein.
- D. Weld Quality - Each completed weld shall have full penetration and complete fusion and be free of cracks. The total area of internal defects such as porosity and slag inclusions shall not exceed 60 mm² (0.09 square inches) and the largest single porosity or slag defect permitted shall not exceed 4.5 mm (0.180") in diameter.
- E. Hardness - The hardness of the weld shall be measured on the head of the rail in the center of the weld in accordance with ASTM E 10. The Contractor must make every effort to produce welds with uniform hardness relative to the parent metal.
- F. Welding Supervision - All welding shall be performed under the direct supervision of a welding foreman or supervisor with a minimum of five years documented experience supervising field welding. In addition, a manufacturer's representative, experienced in thermite and/or mobile electric-flash butt welding, as appropriate for the welding method

being used, shall be present at the job site and shall witness the making of at least the first 8 acceptable thermite and/or mobile electric-flash butt welds.

G. Welding Requirements

1. Rail End Preparation - The rails to be welded shall be cleaned of all grease, oil, dirt, loose scale and moisture to a minimum of 150 mm (6") back from the rail ends, including all the rail surface, by use of a wire brush, to completely remove all dirt and loose oxide, and by use of oxy-acetylene torch under a minimum temperature of 120C (250°F) to remove any grease, oil or moisture. The face of the rail ends shall be aligned and arranged at right angles and cut by using a power actuated saw, or abrasive rail cutting machine, and further cleaned to remove all scale, oil and grease.
2. Remove rust by use of a power actuated grinder with abrasive wheel for 50 mm (2") on each side of the weld. Rail ends shall show no steel defects, dents, or porosity before welding. All burrs and lipped metal which would interfere with the fit of the mold shall be removed.
3. Weld Gap - The minimum and maximum gap shall be in accordance with the Specifications for the type of thermite or mobile electric-flash butt weld being made, and as provided by the manufacturer of the weld kit or the mobile electric-flash butt welding plant. The minimum measurement shall be made with a go or no go gauge made of the specified dimensions for the thermite or the mobile electric-flash butt process used. The gap must be adjusted if under the minimum or more than 3 mm (1/8") over the specified gap.
4. Sealing the Molds - No mold sealant or luting Material shall be introduced into the weld chamber.
5. Bolt Holes - No holes shall be made or included in the ends of the rail to be welded.
6. Preheating - The rail ends shall be standard preheated, prior to welding, to a sufficient temperature and for sufficient time, as indicated in the approved procedure Specification, to ensure full fusion of the weld metal to the rail ends without cracking of the rail or weld. The rail temperature shall be checked by the use of tempilsticks, or as directed by the Engineer. Only standard preheat will be allowed.
7. Post heating - The molds for thermite field welds shall be left in place after tapping for sufficient time to permit complete solidification of the molten metal and proper slow cooling to prevent cracking and provide a complete weld with proper hardness and ductility.
8. Weather - Welding shall not be done during periods of precipitation, winds of 40 kph (25 mph) or more, or electrical activity except by permission of the owner.
9. Other Work - During the setting up and actual welding, other Work which would in any way move, vibrate, or otherwise interfere with the welding outcome will be prohibited.

10. Storage of Thermite Welding Materials - Crucibles, molds and thermite mix portions shall be stored in a dry location in order to prevent moisture contamination. Thermite mix portions stored beyond their shelf life shall not be used.

H. Location - The Contractor shall locate field welds in accordance with the following:

1. Field welds in opposite rails shall be staggered a minimum of 1.50 m (5') for connecting CWR strings and a minimum of 0.60 m (2') at all other locations.
2. Field welds shall not be located within 3.0 m (10') of a bolted rail joint.
3. Field welds shall not be positioned within 75 mm (3") of a support tie.
4. Field welds shall not be located within 3.0 m (10') of another field weld on the same rail or within 2.40 m (8') of a plant weld on the same rail, unless approved by the owner.

I. Alignment

1. The ends of the rails to be welded shall be properly gapped and aligned to produce a weld which will conform to the following alignment tolerances. The rail gap and alignment shall be held by a hydraulic rail puller/expander and alignment jig without change during the complete field welding cycle.
2. Alignment of rail shall be done on the head of the rail:
 - a. Vertical alignment shall provide for a flat running surface. Any difference of height of the rails shall be in the base.
 - b. Horizontal alignment shall be done in such a manner that any differences in the width of heads of rail shall occur on the field side.
3. Horizontal offsets shall not exceed 1 mm (0.040") in the head and 3 mm (0.125") in the base.
4. Surface Misalignment Tolerance:
 - a. Combined vertical offset and crown camber shall not exceed 1 mm (0.040") per 0.30 m (foot) at 15C (60F).
 - b. Combined vertical offset and dip camber shall not exceed 0.25 mm (0.010") per 0.30 m (foot) at 15C (60F).
5. Gauge Misalignment Tolerance - Combined horizontal offset and horizontal kink shall not exceed 1 mm (0.040") per 0.30 m (foot) at 15C (60F).
6. 01230.49 Finishing - The weld shall be finished with a rail mounted rail head grinder specifically designed for the Work. Finishing shall conform to the following tolerances:
7. Top of rail head, + 0.25 mm (0.010") to - 0 mm (0") of the parent rail section.
8. Sides of rail head, \pm 0.25 mm (0.010") of parent rail section.
9. The balance of the rail section shall be finished with a hand-held grinder as required to remove notches, protrusions, gouges, visible cracks and other defects. All grinding shall

blend to the parent rail section and shall not overheat the steel. Heavy grinding shall be completed while the steel is still hot from welding. Remaining weld shall not protrude more than + 3 mm (+ 1/8") of parent rail section at base and sides.

3.2 Quality Assurance

- A. Weld Numbering: Each weld shall be given a number in sequence as the welding progresses. The number shall be painted 50 mm (2") from the finished weld on the field side of the rail. Defective welds which are replaced shall be given a new sequential number. This number shall be recorded in the field welding records.
- B. Field Welding Record: Field welding records shall be maintained by the Contractor and submitted to the Engineer on a daily basis during the production of field welds. These records shall include:
 - 1. Date and time welded.
 - 2. Weld number and location by station stating track and rail.
 - 3. Type of joint - Std to Std, HSHM to HSHM, Std to HSHM.
 - 4. Contractor's welding personnel.
 - 5. Engineer's representative.
 - 6. Manufacturer's representative.
 - 7. Rail gap (nearest 1.5 mm [1/16"]).
 - 8. Weather, air and rail temperature.
 - 9. Inspector's name, date of inspection and inspection results.
- C. Qualification of Welding Crew: Prior to production welding, each crew, including foreman or supervisor of that crew, shall prepare a qualification weld in 51R1 rail at the expense of the Contractor. The weld shall be prepared in accordance with the approved procedure Specification and will be witnessed by the Engineer.
 - 1. Testing: Qualification weld shall be visually inspected and tested by UT and magnetic particle and for hardness.
 - 2. Acceptable Criteria: Weld quality requirements of this Section.
 - 3. Test Record: The test record shall contain the names of the crew members, including foreman or supervisor of that crew, who performed the qualification weld and briefly describe their specific duties. The test records shall also show results of ultrasonic and magnetic particle testing. All performance qualification records shall be submitted to the Engineer at least 14 Days prior to production welding. Production welding shall not commence until qualification test welding records have received written approval by the owner.

4. Requalification - The Owner reserves the right to require the requalification's, at the Contractor's expense, of any crew of welders whose Work fails to meet the specified requirements.

D. Weld Inspection Testing

1. All field weld inspection and testing shall be carried out by an independent testing service, selected by and at the expense of, the Contractor. The testing service and their testing program and procedures shall be subject to the approval of the owner.
2. The Contractor shall submit a copy of his agreement with the testing service to the owner for approval. The agreement shall specify that the testing agency is directly responsible to the owner, that all subsequent communication between the testing services and the Contractor regarding the Work under this Contract shall only be through the owner, and that the agreement shall run for the duration of the Contract and can only be terminated by the owner.
3. Testing service personnel performing non-destructive examination (NDE) shall be certified as Level II or III for NDE methods in accordance with ASNT CP-189.
4. The testing service shall certify whether or not each weld meets the quality criteria immediately following its inspection, and shall indicate acceptance or rejection by marking the tested weld. Written reports shall be submitted to the owner within five Days of testing a weld. The owner will forward copies to the Contractor.
5. Unless otherwise allowed for by the owner, inspection and testing results of field rail welds shall be no further than 10 welds behind the production of welds.

E. Weld Inspection

1. Each weld shall be visually inspected to check for surface defects such as cracks and to determine conformance with the alignment and finishing tolerances herein.
2. Acceptance Criteria
3. Weld Quality
4. Alignment
5. Finishing
6. Inspection Procedures: The testing service shall prepare an inspection program for approval by the owner. The program shall include a description of proposed procedures, equipment and reports.

F. Ultrasonic Weld Testing

1. All welds shall be ultrasonically tested (UT) over the entire cross section of the head, web and base. The UT equipment shall meet the requirements of AWS D1.1, Paragraph 6.17. The procedure shall meet the requirements of ASTM E 164. Prior to performing production UT of welds, all UT technicians shall demonstrate to the satisfaction of the

Engineer that they can discern and identify indication produced by slag, porosity, lack of fusion, and cracks.

2. Testing Procedures: The testing service shall prepare a testing program for approval by the Engineer. The program shall include a description of the proposed procedures, Materials, equipment, safety requirements and report.
3. Acceptance criteria shall be as follows:
 - a. Welds showing a response at any level that is identified as a crack or lack of fusion shall not be acceptable.
 - b. Welds showing a response that is less than 50% of the primary reference level shall be acceptable.
 - c. Welds showing a response greater than 50% but that do not exceed the primary reference level are acceptable, providing that all of the following apply:
 - 1) The defects are evaluated as slag or porosity.
 - 2) The largest defect does not exceed 4.5 mm (0.180") in its largest dimension.
 - 3) The total area of the defects does not exceed 60 square mm (0.09 square inch).
 - 4) The sum of the greatest dimension of defects in a line does not exceed 9.5 mm (3/8").
 - d. Welds showing a response that exceeds the primary reference level shall not be acceptable.
4. Test Report: Each weld examined shall be recorded on a report form which includes as a minimum the following information:
 - a. Technique Sketch
 - b. Type of Equipment, Size of Transducer, Frequency, Angle
 - c. Calibration Data
 - d. Defect Description - Depth, Location, Size, Character
 - e. Equipment Identification - Serial Numbers
 - f. Name of Operator
 - g. Date of Inspection

G. Magnetic Particle Testing

1. All welds shall be magnetic particle tested (MT). The magnetizing equipment shall be an electromagnetic yoke meeting the following requirements:
 - a. DC lift capacity of 180N (40 lbs.), and/or
 - b. AC lift capacity of 45N (10 lbs.) at the maximum pole spacing.

- c. The procedure shall meet the requirements of ASTM E 709.
 - d. All weld surfaces shall be tested except the underside of the rail base.
 - 2. Testing Procedures: The testing service shall prepare a testing program for approval by the Engineer. The program shall include a description of the proposed procedures, Materials, equipment, safety requirements and report.
 - 3. Acceptance Criteria: The weld quality shall meet the requirements of this Section.
- H. Re-welding
- 1. Welds rejected during inspection and/or testing shall be cut out and rewelded if possible, or replaced with at least a 19' (6.0 m) rail welded in its place in accordance with this Specification.
 - 2. Minor defects may be repaired by qualified welders in accordance with repair procedures approved by the Engineer.
- I. Cleanup: Upon completion of each weld, the Contractor shall clean the streetcar right-of-way of all welding debris, including discarded molds, slag, discarded equipment and any other debris that accumulated during the Work.

PART 4 - MEASUREMENT

- 4.1 General: No measurements will be made for Field Rail Welds installed and accepted. These items shall be considered incidental to the Embedded Track Construction –TF and Embedded Special Trackwork-LS units.

PART 5 - PAYMENT

- 5.1 General: No Payment will be made for Field Rail Welds. Rail welding shall be incidental to Sections 34 11 23.33, and 34 11 29.10.

END OF SECTION

34 11 23.31

SPECIAL TRACKWORK DESCRIPTION

PART 1 GENERAL

1.1 Description

- A. This section specifies the furnishing of turnouts and rail joints for paved track installation, including flexible tongue rails, stock rails, closure rails, complete frogs, turnout support plates, switch throw mechanisms and other components as indicated in the Contract Drawings. Supplier shall manufacture, test and furnish all parts, labor, tools, material, equipment, facilities and transportation to supply, deliver, unload and place into storage all trackwork materials in accordance with these specifications.
- B. Turnouts and rail joints procured under this contract will subsequently be installed in concrete or asphalt paved streets on the El Paso Streetcar system.
- C. Design of trackwork shall be suitable for operation of a streetcar vehicle on paved streets. The track gauge shall be as shown in the Contract Drawings.
- D. Curved girder rail which is part of the trackwork unit shall be furnished as part of the unit.
- E. To the maximum extent possible, use standard trackwork components common to other light rail transit systems.
- F. Switch throw mechanisms and earth boxes shall be furnished with turnouts.

1.2 Reference Standards

- A. The following Codes, Regulations, Reference Standards and Specifications in effect on the bid due date shall apply to work included in this section:
 - 1. UIC: International Union of Railways Code.
 - 2. VDV: Association of German Transport Operators
 - 3. EN 14811: European Standard "Railway Applications – Track – Special Purpose rails - Grooved".
 - 4. ASTM: American Society for Testing and Materials.
 - 5. AASHTO: American Association of State Highway Transportation Officials

1.3 Submittals

- A. Submit the following in accordance with paragraphs 34 11 23.31.10 and 34 11 23.31.11 of this Section:

1. Design Report
 2. Shop Drawings
 3. The Supplier shall provide installation instructions and maintenance recommendations for turnouts, switch mechanisms, crossings and rail joints.
- B. Provide the following reports and procedures:
1. Operating and Maintenance Manual for proposed switch mechanisms. This manual must include installation instructions, descriptions of all parts, required maintenance activities, methods to adjust any variable components and a troubleshooting guide for possible malfunctions.
 2. Field welding requirements and installation procedures, including required Brinell hardness.
 3. Sequence of field welding for turnouts.
 4. The color code identification system for turnouts as specified in paragraph 34 11 23.31.15.

PART 2 PRODUCTS

2.1 Shop Drawings

- A. The Supplier shall submit shop drawings for turnouts, switches, frogs, switch throw mechanisms, rail joints, and miscellaneous trackwork materials that are of its own manufacture or any of its proposed subcontractors, and that will satisfy the requirements of this Section. These Shop Drawings shall be submitted before fabrication. Fabrication shall not commence before approval.
- B. The Supplier shall submit to the Engineer for approval 5 sets of Shop Drawings showing the component details and assembly plans. Fabrication prior to approval will be at the Supplier's risk.
- C. Shop Drawings shall reference component model numbers when appropriate. Where components are not detailed on the Shop Drawings, the drawings shall contain a correct reference to detailed drawings and the referenced drawings shall be included with the submittal.

2.2 Design Reports

- A. The Supplier shall prepare within 30 days after Notice to Proceed a Design Report containing proper calculations and back-up data sheets to verify that the proposed turnout designs are compatible with the streetcar vehicles as described in the contract drawings. Also included shall be typical drawings and catalog cuts of the Supplier's proposed materials.

- B. The Design Report shall contain full details of the Supplier's Quality Control Program (QCP).
- C. The Design Report submittal will be reviewed for approval by the owner and the results of this evaluation shall be considered for the Shop Drawing submittals and approved by the owner before fabrication.

2.3 Girder Rail

- A. All rails to be provided by the Supplier shall be new girder rail manufactured in accordance with EN 14811.
- B. All rails shall be supplied with blind ends for welding except for rail with bonded insulated joints and temporary joints in turnouts, which shall be furnished as shown in the Contract Drawings.
- C. Girder rail shall be 51R1 in accordance with EN 14811.
- D. All rails used in turnouts shall be grade R290GHT per EN 14811.
- E. Rail ends shall be cut square to the vertical axis of the rail. A tolerance of 1mm out of square from the base to the head will be permitted.

2.4 Turnouts

A. General

- 1. All turnouts shall be delivered complete with frogs, single or double tongue switches, closure rails, switch throw mechanisms and all other material as indicated on the Contract Drawings.
- 2. All turnouts shall be manufactured from 51R1 rail section.

B. Castings

- 1. The chemical composition and physical qualities of cast steel and cast iron shall conform to the requirements of the latest recommended specifications of ASTM for each of these materials unless otherwise noted.
- 2. Cast steel accessories, fittings, braces, washers, spring housings and other parts not exposed to wheel wear shall conform to Grade 60-30 of ASTM Designation A27. Parts of the track structure exposed to wheel wear shall conform to Grade 80-40 of ASTM Designation A 148.
- 3. Gray iron castings shall conform to ASTM Designation A48, Grade 30B.
- 4. Malleable iron castings shall conform to ASTM Designation A47, Grade 32510.

5. A report on the type of castings used representing the product shall be given to the Owner.

C. Tongue Switches

1. Tongue switches shall be double tongue rolled and flexible deflecting devices with key fastened heels. Switch shall be single tongue for 25M half-switches (S1 and S2).
2. Tongue rails shall be made from steel with a chemical composition which will allow for heat treating for head hardening application or equivalent, furnished by the Supplier. Head hardening shall produce a running surface (rail wheel tread and wheel flange) equal to a BHN from 340 to 380 (1150 to 1290 N/mm²). Testing shall be performed in accordance with VDV Specification OR 14.3.1 to verify this hardness. Test results shall be submitted to the Owner for approval.
3. Single and Double tongue switches shall be compatible with the switch throw mechanisms as specified in Section 34 11 23.33.
4. The base of the tongue and the tongue bed shall be machined to an even and true surface. Special care must be taken to ensure that these parts shall have an equal and true bearing on the tongue and heel beds so that no tendency to rock exists. The tread of the tongue shall be uniform from point to heel.
5. Tongue switch ends shall be compatible with the connecting rail section and shall be removable for maintenance requirements.
6. Provision shall be made for the manual operation of all switches.
7. A report of hardness determinations representing the product shall be given to the Owner.

D. Frogs

1. Frogs shall be of solid block machined steel type with electric shop welded girder rail extensions. Frogs shall conform to VDV Specification OR 14.3.1.
2. Frogs shall be made from a steel which shall produce a running surface (rail wheel tread and wheel flange) hardness equal to a BHN from 320 to 360 (1100 to 1224 N/mm²). Testing shall be performed in accordance with VDV Specification OR 14.3.1 to verify this hardness. Test results shall be submitted to the owner.
3. A report of hardness determinations representing the product shall be given to the owner.
4. Frog arm ends shall be compatible with the connecting rail section and shall be blind ended for welding.

- E. Switch Throw Mechanism: All switches shall be furnished with either a manual or powered switch throw mechanism in accordance with Section 34 11 23.33.
- F. Frog Guard Rails: Rails adjacent to frogs must have flangeway widths that will provide proper guarding of the frog point. The geometry of all guard rails shall be indicated in the design report and shall include proposed flangeway dimensions.
- G. Welding and Welding Materials
 - 1. All components shall be electric flash butt welded in the Supplier's shop wherever possible within the constraints of shipping.
 - 2. The Supplier shall identify all special requirements for field welding and include with written installation procedures.
 - 3. The Supplier shall provide a drawing with the Preliminary Design Report indicating the location, lengths and types of rail sections. The drawing shall also detail the location and types of joints to be shop welded, joints to be field welded and bonded insulated joints.

2.5 Miscellaneous Materials

A. Special Plates

- 1. The Supplier shall furnish all special plates required for installation of tongue switches, frogs and other special trackwork items as indicated in the Contract Drawings.
- 2. Special plates may be part of housing support. Special plates shall be connected to rails by clips. Rails shall not be welded to support plates.

B. Bolted Joints shall be as shown in contract plans or as approved by the owner.

2.6 Identification Marking

- A. The Manufacturer's name or trademark shall be marked on each major component in a permanent manner. Markings shall be made in a manner that will ensure their complete legibility.
- B. All components shall be clearly and permanently marked with part identification consistent with part identification shown on the Contract and Shop Drawings.
- C. Each turnout component, tongue rails, tongue beds, frogs, closure rails and cartons containing loose fastenings shall be individually identified to show specific turnout identification number.
- D. To assist in the installation of trackwork units, rail ends shall be identified by joint number as shown on the Shop Drawings. An identification system shall be used to identify individual turnouts and their components.

- E. The identification system and method of application shall be submitted to the owner for approval and shall be specified on the Shop Drawings.

2.7 Spare Parts

- A. Special trackwork spare parts for emergency standby stock shall be provided for turnout components as follows:
 - 1. Provide the following pairs of right and left-hand switch points as spares.
 - a) One pair of switch points for 25M RH turnout.
 - b) One pair of switch points for 25M LH turnout.
 - 2. Provide the following frogs as spares. Spare frogs shall be provided with 12-inch longer heel length and 12-inch longer toe length.
 - a) One straight frog for 25M RH Straight turnout.
 - b) One straight frog for 25M LH Straight turnout.
 - c) One curved frog for 25M RH Continuous curve turnout.
 - d) One curved frog for 25M LH Continuous curve turnout.
 - 3. Provide, as spares, one single point and one single frog for each unit #S1, #S2 and # S3 Maintenance Storage special Trackwork.
 - 4. All special trackwork spare parts to be provided as emergency stand-by stock shall be delivered to a designated storage area to be provided by the owner.

PART 3 EXECUTION

3.1 Fabrication

- A. Special trackwork shall be fabricated in accordance with the approved final shop drawings and quality control program.
- B. Tolerances in Manufactured Turnout Components shall comply with tolerances described in VDV OR 13.4 and as listed below. If these tolerances conflict, VDV tolerances will govern.
 - 1. Length
 - a) For tongue rails: $\pm 3\text{mm}$
 - 2. Expanding Measurements--allowance for thermal expansion.
 - a) In switches: $\pm 1\text{mm}$

- b) In frogs: $\pm 2\text{mm}$
- 3. Grooves
 - a) Depth: $+ 0.5\text{mm}/- 1\text{mm}$
 - b) Width (straight rail): $\pm 0.5\text{mm}$
 - c) Width (curved rail): $\pm 1\text{mm}$
- 4. Joint Bar Holes
 - a) Diameter: $\pm 1\text{mm}$
 - b) Spacing: $\pm 2\text{mm}$
- 5. Joints, Rectangular or Radial
 - a) Deviation for rails: $\pm 0.5\text{mm}$
 - b) Joint planing of rail ends: Up to $+2\text{mm}$
 - c) Deviation from rectangularity: $\pm 0.5\text{mm}$
- 6. Mountings
 - a) Length: $\pm 20\text{mm}$
 - b) Depth: $+ 0.5\text{mm}/- 1\text{mm}$
- 7. Running Edges
 - a) Forming of running edges of the flat groove with smallest rounding: 2 mm
 - b) Tolerances: $+ 1\text{mm}/- 0.5\text{ mm}$
- 8. Drilled holes in rail - rods, insulated joints, electrical boxes and all others
 - a) $+ 5\text{ mm}/- 1\text{ mm}$
- 9. Machining frogs and tongue rails
 - a) Running surfaces machined to conform to section of connecting rail.
- 10. Electrically butt-welded and/or aluminothermically welded joints
 - a) True to line, all extraneous metal removed.

- 1) Horizontal offsets: Not to exceed 1mm in the head and 3mm in the base.
- 2) Surface misalignment tolerance:
 - (a) Combined vertical offset and crown camber: Not to exceed 1mm per 300mm.
 - (b) Combined vertical offset and dip camber: Not to exceed 3mm per 300mm.
- 3) Gauge misalignment tolerance: Combined horizontal offset and horizontal kink camber not to exceed 1mm per 300mm.

11. Tongue rail mating

- a) Tongue rail to be machined to contact with stock and splice rails with 1mm tolerance.

12. Tongue rail bearings

- a) Tongue rail to be continuously supported.

13. Miscellaneous tolerances in switches - Wedge plates and inserted filling wedges

- a) Position under running surface of rail 3 to 5mm, width + 0/- 3mm.

14. Switch throw mechanism box within switch

- a) Position 3mm, \pm 1mm, below running surface of rail.

3.2 Inspection of Trackwork

- A. All material furnished in this Contract shall be presented for inspection at the place of manufacture. For the inspection of Trackwork, these specifications and approved Shop Drawings shall control.
- B. The Supplier shall afford the owner access and, without charge, all necessary facilities to examine the work, at any time during its progress, as well as the finished product, to satisfy himself/herself that the materials comply with these Specifications. Regular examination of the product will take place during normal working hours.
- C. The Supplier shall provide the owner with templates to check flangeways, rail end drilling and switch rail planing. The design of the templates shall be such that using them will be easy and quick, requiring only one person for the operation.
- D. Material for inspection shall be presented in a safe area away from excessive noise and manufacturing activities. Excessive noise shall be considered any sound or sounds in excess

of 60 dB. The Supplier shall provide labor to facilitate inspection of the top, sides and bottom of frogs and switches.

- E. Before any of the work of a layout is shipped, the entire special trackwork unit (including switch throw mechanisms) shall be assembled on the Supplier's layout floor according to the approved Shop Drawings. A special trackwork unit is a complete unit as shown in the Contract Drawings. The layout shall be inspected by the owner and checked to ensure proper identification, fit and conformity with the Contract and Shop Drawings and this Specification. Any allowable difference in engineering data, length of pieces, etc. shall be noted on the final Shop Drawings submitted by the Supplier for installation purposes. The temperature of the atmosphere at the time of assembly shall be noted on the drawing. No bracing will be permitted to hold parts to gauge or alignments during inspection.
- F. The Supplier shall give the owner written notice for inspection at least twenty one (21) working days in advance of availability for inspection.

3.3 Packaging and Shipping

- A. All loose items and fittings shall be banded, bundled or boxed in packages suitable for re-handling by a 3 ton forklift truck.
- B. Frogs, plates, double tongue switches, switch throw mechanisms and rails shall be packaged together for each trackwork unit and marked with the appropriate identification number.
- C. Trackwork Units shall be located and identified as shown on the Contract Drawings.
- D. All trackwork material shall be protected from salt water. This protection shall not be accomplished by painting the rail.
- E. Material shall be shipped to El Paso, TX, unloaded and transported to a storage site within one mile of the project, as designated by the Contractor.

PART 4 MEASUREMENT AND PAYMENT

- A. All special track work materials, including spare parts, packaging and shipping, described in this Section will be incidental to Measurement and Payment of Section 34 11 23.33, Embedded Special Trackwork.

END OF SECTION

34 11 23.33

Embedded Special Trackwork

PART 1 - GENERAL

1.1 Summary

The Work in this Section includes the installation of embedded special trackwork consisting of furnishing and installing turnout units, concrete track slab, support ties and fasteners, loading, handling, and placement of special trackwork units, elastomeric encapsulation of special trackwork components, furnishing and installing rail boot and elastomeric materials, furnishing all other material, labor and equipment for a complete-in-place installation as shown on the Contract Drawings and as specified herein.

1.2 Related Sections

TXDOT	Standard Specifications for Construction and Maintenance of Highways, Streets and Bridges
200 ITEMS	Subgrade Treatment and Base
300 ITEMS	Surface Courses and Pavements
400 ITEMS	Structures
500 ITEMS	Miscellaneous Construction

1.3 References: The following Codes, Regulations and Reference Standards in effect on the bid due date apply to Work included in this Section:

A. AREMA - American Railway Engineering and Maintenance-of-Way Association.

1. Manual for Railway Engineering.
2. Portfolio of Trackwork Plans.

B. ASTM - American Society for Testing and Material.

C. AASHTO - American Association of State Highway Transportation Officials.

D. ANSI - American National Standards Institute

1.4 Submittals

A. Submittals - Submittals shall be made in accordance with the requirements as specified herein.

1. Work Plans for construction of Embedded Special Trackwork.
2. Shop fabrication drawings, to be submitted prior to fabrication.
3. Quality Control Plan in accordance with approved Project CQMP.

4. Vehicle wheel profile report.
- B. Material Supplier Installation Instructions - Contractor shall make available instructions issued by suppliers for the installation of materials and equipment furnished by the Supplier or Subcontractor to the owner. These materials include turnouts, rail boot, and elastomeric grout.
- C. Reference Drawings - In the event there is a discrepancy between the Manufacturer's Shop Drawings for turnouts and the Contract Drawings, the information shown on the approved Manufacturer's Shop Drawings shall prevail.

PART 2 - PRODUCTS

2.1 Materials

- A. Materials to be Furnished by the Contractor
 1. Turnouts shall be in accordance with Section 34 11 23.31 and the Contract Drawings.
 2. 51R1 Rail shall be in accordance with Section 34 11 13.
 3. Support ties and plates for Turnouts shall be in accordance with Section 34 11 29.10.
 4. Rail for turnouts only as identified on track drawings.
 5. Elastomeric grout for special trackwork encapsulation shall be in accordance with Section 34 11 23.50.
 6. Insulated Joints shall be in accordance with Section 34 11 93.10.
 7. Concrete track slab and infill pavement shall be in accordance with the Contract Drawings.
 8. Welding kits for 51R1 and block rail sections.
 9. Penetration boots, hoses, and stainless steel clamps for electrical conduits and drain lines.
 10. Rubber Boot and cuff extrusions shall be as specified herein.
 11. Cross bonding shall be in accordance with Section 34 11 05.
 12. Hand throw mechanism for turnout with double flexible tongue switch blades shall be Hanning & Kahl Model HWU42 or approved equal. Hand throw mechanism for turnout with single tongue switch blade shall be as per turnout manufacturer's requirements.
 13. Mechanism for powered switches shall be Hanning & Kahl Model HWE 61 or approved equal. Supply and installation of powered switch machine shall include the following:

- a) Contractor to coordinate with the City of El Paso and/or with the utility provider where to source the power supply of the switch machine to be routed into the switch control cabinet and then into the switch machine.
- b) Switch machines blocking circuits (single switch controller) systems design, installation, programming and testing shall be in accordance with the switch machine manufacturer.
- c) Contractor supplied switch control cabinet and underground conduits requirements shall be installed at locations shown on the track plans.
- d) Contractor's installation of blocking circuit's track components (e.g. track boxes, cable connection to rails, wiring and conduits requirements) on track slab shall meet the requirements of Section 34 11 29.10 Embedded Trackwork and manufacturer's recommendations.
- e) Blocking circuit design shall be coordinated with the requirements of specification Section 34 71 29.10.

14. Any and all other Material as required to provide a complete installation.

B. Elastomeric Grout shall be in accordance with Section 34 11 23.50

C. Rubber Boot and Cuff Extrusions shall be in accordance with Section 34 11 29.10

2.2 Equipment

A. Tools and Equipment

- 1. On-track equipment shall conform to AREMA Specifications for On-Track Roadway Machines and Work Equipment. Contractor shall not use on-track equipment that is incompatible with proposed track geometry.
- 2. Clearance for the Contractor's on-track equipment shall conform to the clearance requirements of the streetcar vehicle as defined in the Contract documents.
- 3. Construction equipment operated on the track slab or the tracks shall be in good repair and with all safety and protective appliances in place and functioning.
- 4. Contractor's equipment shall not exceed the design loads shown. Further information concerning vehicle characteristics will be provided by owner's representative upon request by Contractor. Contractor shall verify that proposed equipment meets these requirements.
- 5. Construction equipment with rail wheels shall not be allowed on the tracks if any of the wheels exhibit a flat spot of length greater than 8% of the wheel diameter.

6. The width of flangeway for all frogs shall be as shown on trackwork drawings. The Contractor's on-track equipment shall be modified, if required, to operate through these flangeways. Damage to trackwork shall be repaired at the Contractor's expense.
7. Equipment for elastomeric grout installation shall be as follows:
 - a) The Contractor shall furnish equipment to provide the manufacturer's specified environmental conditions in the work area during cleaning and application operations where necessary to meet contracted completion schedules.
 - b) Cleaning and application equipment shall be as recommended by the manufacturer and shall be sized to the configuration of the work.

PART 3 - EXECUTION

3.1 Construction

A. General

1. Special trackwork will be gauged and isolated.
2. All turnouts and crossovers shall be equipped with insulated drains for the switch boxes, as shown on the Contract Drawings. All drainage connections through trackway slab shall be PVC piping.
3. Maintain monuments for the duration of the Work. Maintain an accurate surveyor's field book, accessible by the owner at any time, indicating all checks of the trackwork alignment. Record deviations from the design alignment that are accepted by the owner.

B. Embedded Special Trackwork Work Plan

1. The Contractor shall submit a Work Plan for each of the special trackwork locations for review and approval by the owner at least 21 days prior to the installation of special trackwork encapsulation.
2. The Work Plan shall describe the material handling, construction methods, sequence, schedule, environmental constraints, maintenance of access and traffic, and coordination with other Contractors in the vicinity of all Work, including the following:
 - a) Removal of existing conditions, preparation of subgrade and installation of base aggregate.
 - b) Installation of drain and conduit stub ups or modifications.
 - c) Layout of support ties.
 - d) Installation of the encapsulation and track slab.

- e) Assembly of the rail, temporary tie bars, drains, and special trackwork.
 - f) Details of fixtures for positioning special trackwork.
 - g) Setting and supporting track to specified horizontal and vertical alignment within tolerances.
 - h) Installation of concrete track slab and infill.
 - i) Installation of elastomeric grout around rail, extrusion boot and assembly.
 - j) Rail layout plan showing location and sequence of the field welds.
- 3. Provide an installation schedule defining the sequence of operations by which the Work will be performed and the anticipated duration of each operation. Describe each installation operation in detail, indicating the materials, manpower and mechanical equipment needed.
 - 4. Special trackwork installations shall not begin until the owner has accepted the Work Plan.
- C. Preparation of Subgrade - The subgrade shall be formed and prepared as shown on the Contract Drawings and in accordance with TXDOT Standard Specifications 200 ITEMS.
- 1. Aggregate Base Course - Aggregate base course shall be furnished and installed in accordance with TXDOT Standard Specifications.
- D. Turnout and Crossover Units
- 1. Turnout and crossover units shall be installed as specified herein and as shown on the Contract Drawings.
 - 2. Concrete Slab Installation - Concrete track slab installation shall be in accordance with Article 3.2B.
 - 3. Special Trackwork Assembly - The Contractor shall assemble the steel components with temporary tie bars and temporary bolted rail joints in accordance with manufacturer's instructions.
 - 4. Surfacing and Aligning - The assembled turnouts shall be raised and supported to final line, profile, and surface within the specified tolerances. The Contractor shall install bracing to hold the position of the trackwork during temperature changes and subsequent construction operations.
 - 5. Supply and installation of non-powered switch machine shall include the following;
 - a) Earth box and manual hand throw mechanism installation, including installation of its drainage requirements, shall be as per recommended by the hand throw switch manufacturers.

- b) Earth box drain outlet lead pipe should be routed and connected to the nearest storm drain structures or sump per Project drainage plans.
- 6. Earth Box and Switch Throw Mechanism – Turnouts shall include earth box and switch throw mechanism to be installed by the Contractor. Supply and installation of powered switch machine shall include the following:
 - a) Contractor to coordinate the source of switch machine power supply to switch control cabinet with utility provider. Contractor to coordinate with the City of El Paso and/or with the utility provider where to source the power supply of the switch machine to be routed into the switch control cabinet and then into the switch machine.
 - b) Signal Systems blocking circuits design and installation shall be in accordance with the switch machines manufacturers.
 - c) Contractor-supplied switch control cabinet and underground conduits requirements shall be installed at locations shown on the track plans.
 - d) Contractor's installation of blocking circuit's track components (e.g. track boxes, cable connection to rails, wiring and conduits requirements) on track slab shall meet the requirements of Section 34 11 29.10 Embedded Trackwork
 - e) Blocking Circuit design shall be coordinated with the requirement of specification Section 34 71 29.10, TWC System.
 - f) Earth box installation, insulation to rail and drainage requirements shall be per switch machine manufacturer's requirements.
 - g) Earth box drain outlet lead pipe should be routed and connected to the nearest storm drain structures or sump per Project drainage plans.
- 7. Special Trackwork Encapsulation shall be in accordance with Section 34 11 23.50.
 - a) Elastomeric Grout
 - 1) Type 1 Elastomeric grout materials for encapsulation of special trackwork machined parts such a switches and frogs shall be preformed before placement and should be inspected and approved by the Resident owner before delivery to the site.
 - 2) Type 2 Elastomeric grout for filling up rail joints, bond wires, rail boot transitions, and switch operating equipment shall be poured in accordance with manufacturer's instructions to accommodate irregularities within the special trackwork unit.
- 8. Rubber boot and cuff extrusions shall be as specified in Article 2.1c.

- E. Field Rail Welding: All temporary bolted joints within the special trackwork unit, and all rail joints to adjacent track, shall be field welded in accordance with the requirements of Section 34 11 16.
- F. Traction Electrification: Traction power bonds shall be installed as shown on the Contract Drawings and in accordance with Section 34 11 05.
- G. Switch Lubricant: Switch slide plate areas shall be lubricated with a dry graphite, insulating film-type lubricant such as Dixon 500 or as approved by the owner.

3.2 Maintenance

- A. Tolerances: Deviations from indicated gauge, cross level, horizontal line, and profile grade shall conform to the following requirements:
 - 1. Track gauge through turnouts and crossings shall be $56.5'' \pm 1/8''$ unless otherwise shown on the approved shop drawings.
 - 2. Track cross level shall be $\pm 1/8''$ from level or from the cross slope shown in the plans.
 - 3. Deviations from horizontal alignment for paved tracks are as follows:
 - 1) $\pm 1/8''$ in the middle ordinate of a 60' chord.
 - 2) $\pm 1/2''$ total except at passenger stop platforms where total deviation shall be $\pm 1/4''$.
 - 4. Deviation from profile grade shall not exceed $\pm 1/8''$ in a 60' chord or a total of $\pm 1/2''$.
- B. Concrete Slab Installation - Install special trackwork , encapsulation, and track slab as follows:
 - 1. Concrete formwork shall be in accordance with TXDOT Standard Specification 300 ITEMS.
 - 2. Concrete shall be air entrained, in accordance with TXDOT Standard Specification ITEM 360.
 - 3. Tolerance on the elevation of the top of the concrete pour shall be $\pm 3/8''$; on the track slab pour shall be $\pm 1/4''$.
 - 4. Slab penetrations and surface modifications for drainage structures and electrical conduits shall be as shown on the Contract Drawings.
 - 5. Drain channels and inlets for turnouts shall be kept clear of obstructions. Contractor shall provide screens for each inlet.
 - 6. Uniform bearing surface compliance shall be determined after rail is installed to final alignment with all welds, joints, ties, rail clips, anchor bolts and associated components installed and with all threaded elements fully torqued. The concrete bearing surface shall be within longitudinal and cross slopes of not more than $\pm 1/4''$ in 10' of the correct slope.

C. Electrical Tests

1. As the work of this Section and Section 34 11 93.20 proceeds, perform track-to-earth electrical resistance tests on completed track at a minimum of one test per track for each continuous work segment (2,000 foot maximum length), and at all special trackwork.
 2. Track-to-earth electrical resistance tests shall be in accordance with Section 34 11 93.20.
 3. Undertake corrective measures at all locations that do not meet the track-to-earth electrical resistance requirements, as specified. The corrective measures shall extend to the next tested location that meets the specified requirements. The corrective measures shall require removal and replacement of any and all insulating materials in the track, at Contractor's expense, until the requirements of Section 34 11 93.20 are met.
 4. Retest the track-to-earth electrical resistance at the corrected locations, as specified.
- D. Repair Procedures: The Contractor shall submit a repair procedure to the owner to assist the owner in future repair, removal and replacement of materials installed under this Contract. The procedure shall cover at least the following items:
1. Removal methods.
 2. Replacement materials including source, shelf life and current cost.
 3. Bonding methods.
 4. Encapsulation material and other insulating membrane repair methods.
 5. Safety requirements for workers and the public.
- E. Traction Electrification Bonding - Traction power bonds shall be installed as shown on the Contract Drawings and in accordance with the requirements of Section 34 11 05.
- F. Shipping, Handling and Storage of Elastomeric Grout
1. Pourable elastomeric grout shall be delivered to the place of application in the manufacturer's unopened, original containers bearing a legible product designation, batch number and date of manufacture.
 2. All material shall be stored in accordance with the manufacturer's latest published instructions and shall be protected, as required by the manufacturer, from damage, moisture, direct sunlight, and temperatures below or above those recommended by the manufacturer.
 3. Containers of elastomeric grout shall not be opened except for immediate use. Materials in damaged containers shall not be used if the contents were exposed.

4. Materials with a shelf life shall not be used after the manufacturer's recommended shelf life.
5. Trackwork materials shall be stored off-ground on pallets, timber dunnage, platforms, or other approved supports in a manner that will permit easy access for inspection and identification.

3.3 Measurement

- A. General: Embedded Special Trackwork units will be measured by each unit completely installed, tested and accepted within the limits as shown on the plans.

3.4 Payment

Franklin-Stanton Turnout	LS
Oregon-Franklin Turnout	LS
Santa Fe-4 th Turnout	LS
Santa Fe-3 rd Turnout	LS
MF Storage Turnout Units (3)	LS
MF Building Turnout Units (3)	LS

END OF SECTION

SECTION 34 11 23.50

ELASTOMERIC ENCAPSULATION

PART 1 - GENERAL

1.1 Scope

- A. Labor, products, equipment, and services necessary to encapsulation special trackwork units in elastomeric grout for electrical isolation, noise suppression, and vibration dampening purposes.
 - 1. Primary encapsulation: the application of elastomeric material to specified special trackwork components prior to installation of a special trackwork unit.
 - 2. Secondary encapsulation: the application of elastomeric material to rail joints, bond wires, rail boot transitions, and switch operating equipment after installation of a special trackwork unit.

1.2 References

- A. The following Codes, Regulations, Reference Standards and Specifications apply to the Work of this Section.
 - 1. American Society for Testing and Materials (ASTM)
 - 2. Society for Protective Coatings (SSPC)

1.3 Submittals

- A. Submit the following in accordance with the general requirements, and at least sixty (60) days before the scheduled start of special trackwork encapsulation:
 - 1. Shop Drawings showing the design coverage and dimensions of the elastomeric encapsulation for all switches and frogs, and details of the rail boot for encapsulating 51R1 rails attached to the frogs.
 - 2. Performance data for the elastomeric encapsulation material.
 - 3. Detailed descriptions of key aspects of production, including but not limited to:
 - a. Cleaning and preparation of the steel surfaces on the frogs, switches and rails before applying encapsulation materials.
 - b. Forming the encapsulation material around the toe surfaces of the castings for proper match to the design dimensions of the rail clips and leveling beams supplied by the special trackwork fabricator to support the special trackwork and maintain proper alignment, without damaging the elastomer during installation.

- c. Sealing the joining of the rail boots to the encapsulation material to ensure it is properly insulated electrically.
- 5. Detailed installation procedures including:
 - a. Handling and installing the encapsulated special trackwork units to prevent damage to them during installation.
 - b. Protection from damage of the rail boot and encapsulation material during field thermite welding of the 51R1 rails to the encapsulated special trackwork units.
 - c. Field testing procedures to test the installed encapsulated special trackwork units for track-to-earth electrical resistance compliance and acceptance before embedding the units in concrete.
- 6. Procedures for repair of damaged polyurethane coatings.

1.4 Quality Assurance

- A. Develop and maintain a quality assurance program regulating methods, procedures, and processes to ensure compliance with standards of quality required by the Contract Documents.
- B. Inspection and Testing:
 - 1. The products and material incorporated into the work are subject to inspection by the Owner's Representative at the place of manufacture, the shipping point, and the shipping destination.
 - a. Inspection by the Owner's Representative will be performed in such a manner as not to unduly delay the work.
 - 2. Whether or not the Owner's Representative inspects any materials, responsibility for defects or other failures to meet the Contract requirements is the Contractor's.
 - b. Do not consider such inspection as a guarantee of acceptance of any material, which may be delivered later.
 - 3. Complete all required quality control tests, inspections and associated documentation.
 - a. Assume full responsibility for all testing indicated.
 - b. Give the Owner's Representative sufficient notice whenever testing in any form is proposed so he may witness the tests.
 - c. Perform all tests specified herein at no additional cost to the Owner.

- d. Have testing witnessed and certified by a qualified independent testing firm or individual.

C. Quality Control Submittals and Procedures

- 1. Submit the Quality Assurance and Quality Control program to the Engineer prior to production.
- 2. Maintain complete records including:
 - a. The polyurethane material test data for each batch.
 - b. Measurements of the critical areas, including base thickness, clearances for rail joints, bonding wire attachment areas, switch operator, and lock box clearance, as defined in the Approved Design Drawings.
 - c. Final post-cured hardness readings for each encapsulated part.
 - d. Electrical tests for each encapsulated part.

PART 2 - MATERIALS

2.1 Contractor Furnished Materials

A. Elastomeric Materials

- 1. Furnish elastomeric materials for special trackwork encapsulation as specified herein.
 - a. For initial encapsulation use polyurethane that has a pot life long enough to ensure that the polyurethane flows easily around the special trackwork to create a homogeneous covering. Air entrapment shall be minimized.
 - b. For secondary encapsulations use polyurethane that has a pot life of approximately 60 minutes at 70°F.

PART 3 - Construction

3.1 Primary Encapsulation

- A. Prepare special trackwork metal surfaces being encapsulated by cleaning, degreasing, and roughening the metal surface in one operation to produce a surface finish as defined by Steel Structures Painting Council (now the Society for Protective Coatings) SSPC - SP5, blasting to white metal.
- B. Coat the prepared metal surfaces with a metal surface oxidation protection/ metal to urethane bond enhancing material, such as "Chemlok" 213, within 4 hours of cleaning and preparation

provided surface has no visible contamination or oxidation. Protect the prepared metal surfaces at all times until encapsulated to minimize contamination, especially when handling the part.

- C. Encapsulate the specified special trackwork components with specified elastomeric material in a single homogeneous layer to the thickness specifications stated below, without seams, and in a manner that minimizes the effects of contamination, moisture, and high or low temperatures in accordance with manufacturer's recommendations.
 - 1. Keep attachment points for standard rails, switch operating equipment, and bond wires free of encapsulation material.
 - 2. Also encapsulate electric switch operating boxes and switch lock boxes using the process required under this Specification. Keep contact surfaces of the box and the switch free of elastomer to allow for proper fixation. Additionally, keep exterior bolt locations free of elastomer until each box is secured in place, at which point all remaining exposed metal surfaces shall be encapsulated.

3.2 Secondary Encapsulation

- A. After installation of a special trackwork unit, encapsulate rail joints, bond wires, rail boot transitions, and switch operating equipment with the specified elastomeric materials in a manner that minimizes the effects of contamination, moisture, and high or low temperatures in accordance with the manufacturer's recommendations.

3.3 Rail Boot Preparation

- A. The boot at rail boot joints shall be prepared mechanically and chemically for a minimum of 4 inches to obtain a high-strength bond with the polyurethane. An enhancing material, such as "Chemlok" 213, is to be applied to the rail boot surfaces for a minimum of 4 inches back from the joint immediately after cleaning and allowed to dry immediately prior to encapsulation.

3.4 Thickness Specifications

- A. Encapsulation material thicknesses shall meet the thickness specifications shown below and on the Contract Drawings. Areas at the base of the special trackwork shall be encapsulated to work with the rail fixation hardware. Thicknesses on the sides beyond the fixation hardware shall be encapsulated at the top of the trackwork, but they may be thicker in non-critical areas if the effects on the infill concrete are considered. The concrete shall not have any unnecessary stress risers or thin overhang areas because of the encapsulation.
- B. Castings shall be encapsulated to the following dimensions, unless specified differently hereafter or on the Contract Drawings:
 - 1. Underside of casting base = 1/2" ($\pm 1/8$ ") thick
 - 2. Topside of casting base = 1/2" ($\pm 1/8$ ") thick
 - 3. Outside edge of casting base = 1/2" ($\pm 1/8$ ") thick

- 4. Sides and web = 1/2" ($\pm 1/8$ ") thick
- C. Running surface (top of rail) and other areas designated on the Approved Design Drawings, including the side of the rail head on the gauge side of the rail, shall be left bare.

PART 4 - Measurement

4.1 Elastomeric Encapsulation

- A. No measurement will be made for encapsulation of special trackwork.

PART 5 - Payment

5.1 Elastomeric Encapsulation

- A. No payment will be made for encapsulation of embedded special trackwork. The work of this section is incidental to the work of Section 34 11 23.33, Embedded Special Trackwork.

END OF SECTION

34 11 29.10

EMBEDDED TRACKWORK

PART 1 - GENERAL

1.1 Summary

- A. The Work in this Section includes the construction of embedded track (mainline revenue track and maintenance facility non-revenue track) as shown on the Contract Drawings and as specified herein. The Work includes furnishing and placing a concrete track slab with or without reinforcing, furnishing and installation of track and concrete overlay on existing bridge deck of I-10 overcrossings, furnishing and installation of track in trainway bridge deck; furnishing and installing 51R1 and block rail; rail boot and cuffs; support ties; rail clips and composite nylon isolators; insulated joints, field rail welding and grinding; transition rails; track drains; traction power cable connections; elastomeric grout and other materials.

B. Related Sections

TXDOT Standard Specifications for Construction and Maintenance of Highways, Streets and Bridges

1. 34 11 23.33 Embedded Special Trackwork
2. 34 11 16 Welded Track Rails
3. 34 11 05 Systems Rail Bonding
4. 34 11 93.20 Track Electrical Testing

- C. References - The following Codes, Regulations and Reference Standards in effect on the bid due date apply to Work included in this Section:

1. AREMA: American Railway Engineering and Maintenance-of-Way Association
2. Manual for Railway Engineering
3. Portfolio of Trackwork Plans
4. ASTM: American Society for Testing and Materials
5. AASHTO: American Association of State and Highway Transportation Officials
6. AWWA: American Water Works Association
7. FTMS: Federal Test Method Standards
8. AISI: American Iron and Steel Institute
9. UBC: Sections 2402 and 2403

1.2 Submittals

Submittals shall be made in accordance with the general requirements of Section 01 33 00 and as described herein. The Contractor shall submit the following:

- A. Designation of line and profile rail.
- B. Embedded Track Work Plan per article 3.2 C.
- C. Detailed procedure for achieving uniform longitudinal rail stress for the zero stress temperature.
- D. Thermite weld kits and weld grinding.
- E. All electrical test results.
- F. The Contractor shall submit for the elastomeric grout the manufacturer's current published application instructions and the Contractor's detailed written procedures for the owner's review and acceptance 90 Days prior to commencing trackwork. Both documents shall address all of the following items:
 - 1. Identification of all Materials to be used by product number and description.
 - 2. Shipping, storing, and handling.
 - 3. Equipment identification, operation, and maintenance.
 - 4. Surface preparation to attain bond.
 - 5. Mixing, applying, and curing.
 - 6. Weather conditions.
 - 7. Public safety.
 - 8. Touch-up and repair.
 - 9. Quality control implementation.
 - 10. Conflicts between the manufacturer's instructions, applicator's procedure, and the Contract requirements shall be brought to the attention of the owner for resolution.
- G. Prior to commencing trackwork, the Contractor shall submit the following for the rail boot and cuff:
 - 1. Drawings for rail boot and cuff;
 - 2. Length of production;
 - 3. Jointing procedure from boot to boot;
 - 4. Cuff installation and isolation at joints;
 - 5. Material composition of boot and cuff and identification;
 - 6. Isolation values of boot and cuff;

7. Testing results for isolation, tensile, shear strength and shore hardness values.
- H. The Contractor shall submit the following for track support during construction;
 1. Support ties and rail clips for at-grade (bottom up) track construction :
 - a. Drawings of support ties, rail clips, nylon isolators,
 - b. Properties of materials and specifications,
 - c. Clip toe load and pressure transfer to rubber boot
 2. Track Support Fixtures for hanging rails on bridge deck track (top down) construction;
 - a. Drawings of support fixtures beam, rail head grabbing plate and clamp, support bolts
 - b. Rail head grabbing plate clamp should be able to grab and hold block rail (with rail boot) to its final profile during rail embedment pour.
 - c. Properties of materials and specifications
- I. The Contractor shall provide Shop Drawings for a track drain compatible with the proposed track components that will properly drain both flangeways and pavement surface, as shown in the Contract Drawings, for approval by the Owner prior to fabrication and delivery.
- J. The contractor shall submit shop drawings for 51R1 rail that will be pre-bent with roller bending equipment. These drawings shall include the following information:
 1. Curve designation
 2. Start and end stationing of curve
 3. Location of any joints in the curve (by stationing or length along curve)
 4. Width of gaps between rails through curves.
 5. Length of rails within the curve.
 6. Points of curvature (PC, PT, TS or ST).
- K. Rails shall not be pre-bent until shop drawings have been reviewed and approved by the owner. Existing contract drawings may be submitted as shop drawings as long as the information required above has been included on the drawings.

1.3 Quality Assurance and Quality Control

- A. The quality of all Materials and installation of Work shall be confirmed by the Contractor in accordance with the written Quality Control Plan, prepared by the Contractor and accepted by the owner in accordance with approved Project CQMP.
- B. The Quality Control Plan shall define the tests and measurements to be conducted by the Contractor, the instruments and equipment required the frequency of tests, and the documentation of the results. All quality control Work is the responsibility of the Contractor.

- C. The Quality Control Plan shall cover all phases of the Work, from material manufacture to trackwork completion, including at least the following specific items:
1. Material control and batch traceability.
 2. Shipping, handling, and storage controls and measurements.
 3. Equipment maintenance including calibration measurements and tests for contamination of compressed air lines.
 4. Surface preparation measurements.
 5. Environmental measurements such as temperature, dew point, relative humidity, rainfall, etc.
 6. Mixing, applying and curing measurements such as component materials viscosity and density, mixing ratios, and material hardness at various cure times.
 7. Provisions for test failure and retesting procedures.
 8. Track alignment and geometry measurements and control.
 9. Field rail welding and grinding control.
- D. The owner shall have access to witness all quality control tests and measurements and to review all documentation. Contractor shall give notice or schedule to owner when tests are to occur.
- E. Incomplete or inadequate quality control documentation will be sufficient grounds for rejection of installed materials.
- F. The Work of this Section shall be supervised by a superintendent and foreman in charge of trackwork operations, each with 5 years documented experience in embedded track construction.
- G. Track Demonstration Section
1. The Contractor shall install a demonstration section of embedded track to qualify his track Work Plan upon receipt of conditional approval of the Work Plan by the owner.
 2. The demonstration section shall be at least one construction cycle, a minimum of 200 feet in length, and shall be installed in strict accordance with the Work Plan herein. "Construction cycle" is defined as the average duration of construction activity required to completely install embedded track in any one of the areas of the Project.
 3. Upon completion of the demonstration section, the Contractor shall verify conformance with the specified tolerances and track-to-earth electrical tests as specified in Section 34 11 93.20.
 4. Unacceptable demonstration sections shall be repaired or removed and replaced at the Contractor's own expense to conform to all Contract requirements.

5. The demonstration track shall be constructed, fully tested, and accepted to the Specification requirements by the owner prior to initiation of any other track installation Work.
6. Upon acceptance of the demonstration section by the owner as part of the system, the Contractor's key personnel including, but not limited to, the Contractor's Project Manager, superintendent, track crew foreman, inspectors, surveyor, track Subcontractor foreman and quality control manager, shall meet with the owner to review the conduct of demonstration track construction. At the meeting the Contractor and his personnel shall present any revised construction methods from those approved, request any clarification of requirements and criteria, and address any procedural problems or suggest improvement for the owner/Contractor relationship for the duration of the trackwork construction. At the meeting, the owner will establish delivery dates for Contractor revised submittals and other action items arising from the meeting.
7. The owner will produce minutes of the demonstration review meeting that will document the results of the meeting.

PART 2 - PRODUCTS

2.1 Materials

A. Materials Furnished by Contractor

1. New 51R1 and Block Rail in accordance with Section 34 11 13.
2. Elastomeric Grout shall be as specified herein
3. Rail boot and cuffs shall be as specified herein
4. Insulated support ties assembly
5. Gage rods
6. Block rail anchor bolts and rail clip assembly
7. Embedded turnouts in accordance with Section 34 11 23.33.
8. 51R1/Block rail transition rails in accordance with Section 34 11 13.
9. Track drains shall be as shown in Contract Drawings and as specified herein.
10. Track slab concrete shall be 4,400 Class P per TXDOT ITEM 360.2. Trackway bridge overlay concrete shall be 4,400 Class P per TXDOT ITEM 360.2 unless specified otherwise in contract documents. Rail trough infill concrete shall be per Art 2.1E.
11. Steel reinforcement shall be Grade 60 (60,000 psi) deformed bars.

12. Bonded insulated joint kits shall be in accordance with Section 34 11 93.10 except for any insulated joints supplied as part of the special trackwork units described in Section 34 11 23.33.
13. Insulating membrane shall be as specified herein.
14. Any and all other Material necessary to provide a complete installation.

B. Elastomeric Grout

1. Type 1 elastomeric grout shall be used around rail and under base plates as a rail support material. The Shore A hardness shall be between 80-85 when measured in accordance with ASTM D 2240.
2. Type 2 elastomeric grout shall be used for filling and sealing rail joints, bond wires, rail boot transitions and electrical track boxes equipment surrounds. Type 2 elastomeric grout may be used at other locations where stray current control is required, but may not be used in locations where rail support is needed. The shore A hardness shall be between 65-75 when measured in accordance with ASTM D2240.
3. Elastomeric grout shall be a two-component polyurethane material or approved equal consisting of a resin and a suitable hardener, mixed on site per manufacturer's instructions. Elastomeric grout shall be subject to the approval of the Engineer.
4. Provide certification that the cured elastomeric grout possesses hard, elastic, vibration and sound absorbing properties and provides the level of track-to-earth electrical resistance, all as specified herein.
5. Elastomeric grout shall be Icosit KC330 grout, Dural 435 grout or approved equal.

C. Insulating Membrane - Insulating membrane shall be PVC/Elvaloy Nylon-Reinforced Isolation Membrane as supplied by Ironhorse Engineering or approved equal. The material shall be durable and shall not compress under train loads to the point where concrete cracking occurs. The primary purpose of the insulating membrane is to protect surrounding utilities from stray current for the life of the installation (30 years). As such, the membrane shall have a minimum volume resistivity of 1×10^{12} Ohms-cm when tested in accordance with ASTM D 257.

D. Insulated Support Ties Assembly

1. Insulated support ties with nylon fasteners shall be furnished complete for assembly of rail and rail boot.
2. Support ties shall be similar to IHECO (Iron Horse Engineering Co.) Part Number 12.334 steel ties or approved equivalent. Steel ties shall have a minimum width of 5 inches (125mm) and length from 84ft to 90ft to support the rail seat and shall have bending properties equivalent to a C 5x9 channel per ASTM A36 steel. Ties shall be

provided with slotted holes to accommodate an adjustable bolt fixation of 51R1 girder rail at a track gage of 56.50 inches (1435mm). Rail shall be fastened to ties using 7/8 inch diameter-9UNC bolt and nylon fasteners (nylon reinforced plastic clips) or approved equivalent. Support ties shall be furnished with welded 1.25 inches -7 UNC heavy hex nuts for installation of 1.25 inches diameter x 12 inches minimum length – 7 UNC tap bolts for setting track skeleton to its final grade above ground.

3. Steel support ties shall be coated with 3MTM Scotchkote™ 206N Fusion Bonded Epoxy Coating (or approved equivalent) applied in accordance with AWWA C213.
4. Support ties shall be spaced at 10 feet on tangent and curves with a radius larger than 500 feet. For curves 500 feet or less, support ties shall be spaced at 5 foot intervals.
5. Nylon reinforced plastic clips shall be IHECO (Iron Horse Engineering Co.) Part Number 12.310 or approved equivalent. Clips shall be one-piece clips bolted to the steel support ties that securely hold rails and boot in place. Clips must allow for minor adjustments of rail gage during installation.

E. Block rail anchor bolts and rail clips for installation on trainway and/or highway structures.

1. Block rail installation on concrete trough;
 - a. Concrete anchor bolt, nut and washers shall be SAE-J429 steel zinc plated, $\frac{3}{4}$ " diameter-10UNC thread rod x 5 $\frac{1}{2}$ " long epoxy grouted into drilled concrete hole. Drilled hole diameter shall be as per recommended by anchor bolt and epoxy grout supplier. Min embedment of 3 $\frac{1}{2}$ ". Provide as needed flat, helical spring washer and 1 $\frac{1}{2}$ " square beveled washers compatible with $\frac{3}{4}$ " diameter anchor bolt.
 - 1) Epoxy grout shall be two-component, high modulus, high strength epoxy-based structural grout product. Compressive Strength ASTM D695: 7day - 12,000psi. Pullout strength-ultimate ASTM E488 (24hrs) 28000psi.
 - a) Acceptable product "Quikrete High Strength Anchoring Epoxy"
 - b) Or approved equal.
 - 2) Submit anchor bolts assembly product and epoxy grout product for approval by the Engineer.
 - 3) Misplaced, misaligned and damaged rail anchor bolts shall be replaced and be repaired by the Contractor at no cost to the Owner.
 - b. Block-rail rail clip shall be LB Foster Product Part No 128 or approved equal.
 - c. Pair of anchor bolt spacing and offset from gauge line:
 - 1) Maximum 3 feet spacing on horizontal curve with radius less than 500feet and/or on vertical curve with K-value equal or less than 9. K-value = Length of vertical curve/(G2-G1). Block-Rail track installation on Trainway Bridge Decks; Anchor bolt spacing shall be maximum 3 feet.

- 2) Maximum 5 feet spacing on tangent tracks and flatter curves with Radius equal or greater than 500ft. Block-rail installation on I-10 Highway Structure Overpass Decks; Anchor bolt spacing shall be maximum 5 feet.
 - 3) Pair of anchor bolts center lines shall be located at approximately 4 inches (+/- 1/8 inch) offset from each side of the block rail's gauge line. The 4-inches offset to be verified in the field contingent to the actual rail clips and rail boot thickness to be use by the Contractor
- d. Composite materials shim under the rail boot to meet design track profile shall HDPE (High Density Polyethylene) sheet minimum 1/8" thick.
 - e. Rail trough structural concrete infill mix shall be fiber reinforced concrete mix, air entrained material designed to repair highways and highway bridge decks. Compressive strength 28-day 6000psi per ASTM C39. Air content per ASTM C231 5%-8%. Shear Bond Strength per ASTM C882 2500psi. Structural concrete infill top surface shall be screed and then broom for slip resistant finished.
 - a) Acceptable product "Quikrete Fiber-Reinforced Deck Mix"
 - b) Or approved equal.
2. Block rail installation on 12" track slab using support tie.
 - a. Chair rail seat assembly can be installed under the block rail to set the support tie 5" below the track slab surface. Design of attachment of rails to support ties, with or without chair assembly materials shall be as recommended by support tie Supplier to be approved by the Owner prior to acceptance of ties and clip assemblies.
 - b. Support tie maximum spacing: 10 feet

F. Rubber Boot and Cuff Extrusions

1. Elastomeric rubber boot and cuff extrusions shall be preformed continuous extruded elastomeric material with a minimum length of 200 feet (70m). Elastomeric rubber extrusion and cuff material shall be manufactured Santoprene 591-73 W 175 Thermoplastic Rubber or approved equal.
 - a. Test Requirements
 1. Submit certification from a testing laboratory that the material to be installed in track will pass the tests listed below. Test reports indicating acceptable material shall be received by the owner prior to shipment of material to the job site.
 2. Volume Resistivity

Test Method: In accordance with ASTM D 257, at 50 percent relative humidity and 77 degrees F shall be measured for a dry specimen and then for the same specimen after 7 days immersion in a 3 percent NaCl solution. The specimen from the latter test shall only be wiped dry prior to testing

and no more than 1 hour shall elapse between removal from immersion and performing the test.

Acceptance Criterion: 10^{12} ohm-cm minimum

3. Tensile Strength Test

Test Method: In accordance with ASTM D 412

Acceptance Criterion: 1000 psi minimum

4. Chemical Resistance

Test Method: In accordance with ASTM D471, oil swell, IRM 903

Acceptance Criterion: +60 percent by weight maximum

5. Absorption of Moisture

Test Method: In accordance with ASTM D570

Acceptance Criterion: Less than 0.45 percent water absorption by weight.

6. Durometer Hardness Test

Test Method: In accordance with ASTM D 2240, report for cured specimens and specimens aged 24 hours at 75 degrees F.

Acceptance Criterion: Shore hardness A: 65 to 75.

2. The Contractor shall submit certification and test reports from the manufacturer that the installed product will withstand:
 - a. AASHTO HS20-44 loadings in an urban environment for a minimum of 5 years with no failure. Failure is defined as the product not capable of carrying a vehicle or pedestrian in a smooth and safe manner from pavement to rail, requiring replacement or repair of the product.
 - b. The pressure and abrasion of heavy bus and truck traffic with studded tires and/or chains, and to provide a non-skid surface for a minimum of 5 years with no failure.
 - c. That the strength of the adhesive used to join adjacent sections is at least 70% of the cohesive strength of the elastomeric rubber extrusion insert.
3. An acceptable rubber boot and cuff extrusion for encapsulating the rail shall be as supplied by; Iron Horse Engineering Company, PO Box 5398, Suffolk, Virginia 23435

G. 51R1/Block Rail Transition Rail

1. The transition rails shall consist of a machined transitioning rail with sections of the appropriate rail section electric flash butt welded to each end of the machined transition rail as shown on the Contract Drawings. The steel composition, hardness, and wearability of the machined transition rail shall match the same qualities of the adjacent rail.

H. Track Drain

1. The track drains shall be fabricated plastic box or formed concrete that fits adjacent to the rails of one track to drain the pavement surface and the track flangeways. Rail connections must be insulated if track drains are to be installed outdoors.
 2. The track drain shall be as shown in the Contract Drawings.
 3. The track drain assembly shall be manufactured to fit 51R1 rail laid at the specified track gauge of $4'-8\frac{1}{2}" \pm 1/8"$. The drain shall be constructed so that the top of the grate will not exceed $\frac{1}{4}"$ below the top of railhead elevation.
 4. Grate shall allow a 1" gap for rail flangeway and a 1" gap for rail head. Frame and Grates steel materials shall be per ASTM A36. Galvanized per ASTM A123. Studs and bolts per ASTM A307.
 5. Track drain frame and grating; steel plates, angle section and bars shall conform to ASTM A36. Bars conforming to ASTM A108 will be accepted. Track drain frame and grate shall be galvanized. Anchor studs; ASTM A307 or F436 as applicable.
 6. Piping used for track drains shall be HDPE or PVC (ASTM D3034 SDR 35).
- I. Traction Power Cable Connection to rail
1. The traction power connection shall be as shown in the Contract Drawings and as specified in 34 11 05 Systems Rail Bonding.
- J. Concrete Track Slab, Concrete Infill and Concrete Overlay
1. Concrete mixes to be used on the project must be reviewed and approved by the Engineer. ASTM C 452-75 and American Concrete Institute SP-77 "Sulfate Resistance of Concrete" should be consulted in development of these mixes. The maximum allowable chloride concentrations shall be 150 parts per million (ppm) in the total mix (mixing water, aggregate, cement, and admixtures). The concrete mix should result in water and acid soluble chloride concentrations, at the concrete/reinforcing steel interface, do not exceed 0.15 and 0.2 percent by weight of the cement and steel respectively. Contractor shall refer to ACI 222R "Corrosion of Metals in Concrete" on this matter. The Contractor shall also provide documentation concerning the above requirements for precast concrete (including structures) to be used on the project.
 2. Reinforcing and tie-bars shall be deformed bars in accordance with TXDOT Standard Specification ITEM 440.
 3. Concrete track slab maximum aggregate size shall be 1-1/2". Slump shall range from 2 to 5 inches.
 4. Concrete infill on existing rail trough for track installation on trainway bridge deck and concrete overlay for trackway installation on existing I-10 bridge deck shall be as per Structural Plan and specification.
- K. Shipping, Handling and Storage of Elastomeric Materials

1. Pourable elastomeric Materials shall be delivered to the place of application in the manufacturer's unopened, original containers bearing a legible product designation, batch number and date of manufacture.
2. All Material shall be stored in accordance with the manufacturer's latest published instructions, and shall be protected as required by the manufacturer from damage, moisture, direct sunlight, and temperatures below or above those recommended by the manufacturer.
3. Containers of Elastomeric Materials shall not be opened except for immediate use. Materials in damaged containers shall not be used if the contents were exposed.
4. Materials with a shelf life shall not be used after the manufacturer's recommended shelf life.
5. Trackwork Materials shall be stored off-ground on pallets, timber dunnage, platforms, or other approved supports in a manner that will permit easy access for inspection and identification.
6. Operations likely to cause scratching, notching, rubbing, scoring, or striking of the rails during any handling operations shall not be used.

L. Inspection of Materials

1. All material furnished in this Contract by the Contractor shall be presented for inspection at the place of manufacture.

M. Packaging and Shipping of Precurved Rails from Offsite Location

1. Precurved rails shall be wedged and blocked for shipment so as to prevent accidental bending of the rail.

2.2 Equipment

A. Tools and Equipment

1. On-track equipment shall conform to AREMA Specifications for On-track Roadway Machines and Work Equipment.
2. Construction equipment operated on the track slab or the tracks shall be in good repair and have all safety and protective appliances in place and functioning.
3. Contractor's equipment shall not exceed clearance requirements and the design loads. Further information concerning vehicle characteristics will be provided upon request by Contractor. Contractor shall verify that proposed equipment meets these requirements.
4. Construction equipment with rail wheels shall not be allowed on the tracks if any of the wheels exhibit a flat spot of length greater than 8% of the wheel diameter.

5. Tools used in track construction shall conform to AREMA Specifications and Plans for Track Tools, or as approved by the Engineer. All tools shall be calibrated as appropriate for the use.
6. Equipment for elastomeric grout installation shall be as follows:
 - a. The Contractor shall furnish equipment to provide the manufacturer's specified environmental conditions in the Work area during cleaning and application operations where necessary to meet contracted completion schedules.
 - b. Cleaning and application equipment shall be as recommended by the manufacturer and shall be sized to the configuration of the Work.
 - c. Air supply lines shall be equipped with effective traps to remove moisture and oil. Traps shall be bled continuously.

PART 3 - EXECUTION

3.1 Construction

A. General

1. Track construction shall conform to AREMA Specifications for Track Construction except as modified herein. All trackwork shall be insulated and equipped with traction power boxes, as shown in the Contract Drawings.
2. Contractor to provide survey control.

B. Track Alignment and Geometry

1. Profile Rail - The Contractor shall designate right or left rail, while facing in the direction of increasing stationing, to control the grade of all tangent tracks on a Contract-wide basis. The low or inner rail on all curves shall be used to control grade.
2. Line Rail - The Contractor shall designate right or left rail, while facing in the direction of increasing stationing, to control the alignment of all tangent tracks on a Contract-wide basis. On curves the outside rail shall be designated the line rail.
3. After completion of concrete pour No. 1, but before concrete pour No. 2, the Contractor shall perform a survey of the finished rails to determine the actual horizontal and vertical alignments, track gauge and cross level. Any deviations in the final alignment exceeding the embedded track construction tolerances shall be corrected by the Contractor before continuation of the work.
4. If Contractor intends to pour the track slab in one pour, in addition to the above the Contractor shall perform the following:
 - a. Provide sufficient support to prevent uplift during the pour.
 - b. Provide an approved repair method.
5. Maintenance of Monuments - Maintain monuments for the duration of the Work. Maintain an accurate surveyor's field book, accessible by the Engineer at any time,

indicating all checks of the trackwork alignment. Record any deviations from the design alignment that are accepted by the Engineer.

- C. Preparation of Subgrade - The subgrade shall be formed and prepared as shown on the Contract Drawings, and in accordance with TXDOT Standard Specification ITEM 132.3.
- D. Aggregate Base Course - Aggregate base course shall be furnished and installed in accordance with TXDOT Standard Specifications.
- E. Concrete Track Slab Installation shall be in accordance with TXDOT Standard Specification ITEM 360 and as modified below.
 - 1. Install the reinforced concrete track slab as follows:
 - a. Top surface of the concrete will be placed relative to the finished top of rail
 - b. Tolerance on the elevation of the top of rail to adjacent embedment concrete shall be + ¼ inch(6 mm), -0 inch (-0mm).
 - c. Slab penetrations, block outs and surface modifications for drainage structures, boxes and conduits shall be as shown on the Contract Drawings.
 - d. Inspection shall be by the Contractor's personnel who will have responsible charge of the Work. All defects in the base material shall be corrected prior to placement of the concrete track slab.
 - e. The concrete track slab including any reinforcement and tie bars shall be placed as shown on the Contract Drawings, in accordance with TXDOT Standard Specifications and as specified herein.
 - f. Track slab surfaces shall receive a transverse "broom" concrete finish.
 - g. Transverse forms, where required, shall be constructed to allow grout-tight penetration of booted rail.
 - 2. When standard track slab is to be installed on top of existing or modified utility vaults, Contractor shall install structural foam (2 inches minimum) material between track slab and the vault lid below.
 - 3. Bridge Deck new concrete slab, rail trough concrete infill and/or trackway overlay shall be installed in accordance with TXDOT standard specifications and/or as per described here in.
 - a. Bridge deck and rail trough surfaces shall be prepared by applying asphalt sealer remover, scrubbing, chipping, sandblasting cleaned water blasting, or other accepted methods to remove defective concrete, asphalt stains, laitance, dirt, oil, grease, and other foreign matter to achieve sound, clean, and roughened concrete surfaces. Submit the product to be used for removing asphalt stains and/or remnants of asphalt sealers costing on the surface of the existing trough.
 - b. Locate and drill anchor bolts holes within 1/8" of intended offset from gauge line. Diameter and minimum depth of anchor bolt hole shall be as per recommended by anchor bolt and epoxy grout supplier. Rail boot should not be damaged when

drilling the anchor bolts holes. Provide necessary spring washer and beveled washer to provide full toe contact between rail clip and top of block-rail boot.

- c. Install forms for infill concrete to maximum longitudinal length limit as recommended by concrete infill supplier. The tops of such forms shall be 1 inch above the surfaces infill concrete.
- d. Cover concrete areas with protective waterproof covering until ready to place concrete infill and epoxy grout.
- e. Place structural concrete infill and epoxy grout in accordance with the respective manufacturer's instructions and recommendations. Exposed surface of the rail trough structural concrete infill and/or bridge deck overlay shall be screed and then broom finished for skid resistant surface.

F. Rail Installation

- 1. Rail Distribution - The rails shall be loaded from the designated storage area, transported and unloaded at the Work Site in accordance with the recommendations of Chapter 5, Track, of the AREMA Manual. Layout of the rails shall conform to the Work Plan.
- 2. Shop Precurving of rail shall be in accordance with Section 34 11 33. Field bending (horizontally and vertically) of rails beyond the elastic limit of steel should be avoided to prevent rail from springing back to its original straight configuration during field installation.
- 3. Field rail welding shall be in accordance with Section 34 11 16. Girder rail and block rail shall be continuously welded before installation on tangent tracks, sharp horizontal (precurved rails) curved tracks and on short length vertical curves tracks. Closure rails to connect CWRs and special trackwork rails shall be located preferably on horizontal and vertical tangent track or on curve track with horizontal radius greater than 500ft. Field welding of Transition rail shall be as per recommended by the Transition Rail supplier and to located as shown on the Contract Drawings.
- 4. Cutting and Drilling
 - a. Holes or cuts will not be permitted except where shown on the Plans and as specified herein.
 - b. Rails shall be cut square and clean by using rail saws or abrasive cutting discs only. Flame cutting of the rail will not be allowed. Burrs and excess metal on the rail ends shall be removed after cutting by grinding.
 - c. Rails shall not be cut for the installation of a bolted or bonded joint within 10 feet (3m) of a shop weld.
 - d. Holes shall be drilled in accordance with the requirements of AREMA Manual, Chapter 4, "Specifications for Steel Rails." Holes shall not be punched, shot, slotted, or burned with a torch.

5. Destressing Rail
 - a. Rail zero stress (neutral) temperature at final closure and fastening shall be 75° F, +10° F, -5°F.
 - b. The rail shall have a uniform longitudinal stress along the entire fastened length (except at free ends).
 - c. The Contractor shall submit a detailed procedure for achieving uniform longitudinal rail stress for the zero stress temperature specified herein.
 - d. Final closure shall be by a field weld with the rail fully fastened (except immediately adjacent to the field weld as necessary to perform the weld) near or at final elevation and alignment. If post closure rail realignment is required, the Contractor shall provide sufficient longitudinal restraint either side of the location of realignment to assure the rail stress state is not changed by the realignment Work.

- G. Installation of support tie assembly and block rail anchoring shall be as recommended by the support tie supplier and approved by the owner.

- H. Install rail boot and cuff extrusion as recommended by the rail boot supplier. Rail and rubber boot longitudinal separation tolerance gap shall be no greater than 1/16". Rail boot inside shall be clean and free of any debris, chips, concrete or rocks before installation on rails.

- I. Track Drain Installation
 1. Install drains as indicated in the Contract drawings.

- J. Traction Power Cable Connection
 1. Install elastomeric grout as indicated on the Contract drawings and as specified in Section 34 11 05.
 2. Connect electrical cables, boxes and conduits as indicated on the Contract drawings and as specified in the Systems Specifications.

- K. Bonded Insulated Joints
 1. Bonded insulated joints shall not be located closer than 3 inches (75mm) from the end of the insulated joint bar to the face of support ties.
 2. Bonded insulated joints shall be staggered at least 2 feet (0.60m) from the insulated joint on the opposite rail, unless otherwise noted on the Contract Drawings or approved by the Engineer.
 3. Power cables shall be directly welded to web of rail and sealed by elastomeric grout at each insulated rail joint as shown on the Contract Drawings and in accordance with Section 34 11 05.
 4. Bonded insulated joints shall be encased in elastomeric grout for the full length and connected to the rail boot where applicable.

- L. Traction Power Bonding - Traction power bonds shall be installed as shown on the Contract Drawings and in accordance with the requirements of Section 34 11 05

3.2 Field Quality Control and Maintenance

A. Care of the Work

1. Before the final track slab concrete pour, the Contractor shall perform a survey of the finished rails to determine the actual horizontal and vertical alignments, track gauge and cross level. Any deviations in the final alignment exceeding the embedded track construction tolerances shall be corrected by the Contractor before continuation of the work.
2. If Contractor intends to pour the track slab in one pour, in addition to the requirements above, the Contractor shall perform the following:
 - a. Provide sufficient support and restraint to prevent rail uplift during the pour.
 - b. Provide an approved repair method.

B. Installation Tolerances: Deviations from indicated gauge, cross level, horizontal line, and profile grade shall conform to the following requirements:

1. Embedded track gauge shall be 56.5 inches \pm 1/8 inch.
2. Embedded track cross level shall be 1/8" from level or superelevation.
3. For embedded tracks, deviation from horizontal alignment is as follows:
 - a. 1/4 inch in the middle ordinate of a 30 foot chord
 - b. \pm 1/2 inch total, except at passenger stops where total deviation shall be \pm 1/4 inch.
4. Deviation from profile grade shall not exceed \pm 1/4 inch in a 30 foot chord, or a total of \pm 1/2 inch.

C. Trackwork Plan

1. The Contractor shall submit a Track Work Plan for review and conditional acceptance by the owner at least thirty (30) Days prior to the installation of a demonstration section.
 - a. Submit separate Track Work Plans for the following:
 - 1) At-Grade embedded track construction
 - 2) Embedded track construction on bridge decks crossing I-10 freeway,
 - 3) Embedded track construction on bridge decks crossing train way
2. As part of the Track Work Plan, the Contractor shall pay particular attention to the maintenance of a clean track section through all stages of the work. The owner shall be contacted a minimum of 24 hours in advance of all steps of the installation. The

Contractor must assure the owner that the rail has been sealed in a finished installation that is entirely clean and free of debris. Particular care shall be taken to keep the rail boot absolutely clean during installation.

3. The Track Work Plan shall describe the material handling, construction methods, sequence, environmental constraints, maintenance of access and traffic, and coordination with other Contractors in the vicinity for all work, including the following:
 - a. Preparation of subgrade and installation of aggregate base material as specified herein and as shown on the Plans.
 - b. Installation of the concrete track slab, reinforcement if required, joint layout, stub ups and block outs.
 - c. Assembly and installation of the support ties and nylon fasteners, boot, cuffs, rail, and track drains.
 - d. Installation of bonded insulated joints and field rail welds.
 - e. Installation of traction power cable welds to rail.
 - f. Rail Layout Plan showing location and sequence of the field welds.
 - g. Methods to meet the rail temperature requirements.
 - h. Surface finish where applicable, as shown on the Contract Drawings.
 - i. Intermittent electrical resistance tests shall be in accordance with specified criteria for rail to track slab before installation of concrete No. 2 pour, as specified in "Electrical Tests" in this Section.
4. Provide an installation schedule defining the sequence of operations by which the Work will be performed and the anticipated duration of each operation. Describe each installation operation in detail, indicating the materials, manpower and mechanical equipment needed.
5. Provide an itinerary of street closures based upon the installation schedule. Indicate which sections of the streets will require closure and the dates when the various closures will be implemented based on TXDOT Standard Specifications.
6. Final Acceptance of the Work Plan by the owner is contingent upon installation of an acceptable demonstration section. Production track installation shall not begin until the owner has accepted the Work Plan.

D. Final Alignment and Track Inspections

1. The final horizontal and vertical alignment, gauge, and superelevation shall be within the tolerances specified. In order to determine the acceptability of finished track after construction, the parameters specified above will be measured by the Contractor and submitted to the owner. Final measurements must be taken every 100 feet.
2. Track geometry deviations, as disclosed by the inspection specified above, shall be corrected and necessary reinspection shall be performed to ascertain that corrections have been made prior to Final Acceptance.

3. If the Contractor uses the single pour method for the trackway slab, the track profile shall be exact and the rail system shall be secured to prevent uplift. Contractor shall demonstrate that he can control rail alignment and surface finish with one concrete pour and that conditions of Article 3.1;B;4 are met.

E. Electrical Tests

1. As the work of this Section proceeds, perform track-to-earth electrical resistance tests on completed track at a minimum of one test per track for each continuous work segment (2,000 foot maximum length), and at all special trackwork.
2. Track-to-earth electrical resistance tests shall be in accordance with Section 34 11 93.20.
3. An intermediate track-to-base slab test shall be performed every time a track section has been completed, and before the final concrete pour is placed. If Contractor decides to pour track slab in one pour, an approved method for corrective measures shall be in place to meet the track-to-earth electrical resistance requirements.
4. The boot shall be tested for holidays and damage before concrete pour.
5. Undertake corrective measures at all locations that do not meet the track-to-earth electrical resistance requirements, as specified. The corrective measures shall extend to the next tested location that meets the specified requirements. The corrective measures shall require removal and replacement of any and all insulating Materials in the track, at Contractor's expense, until the requirements of Section 34 11 93.20 are met.
6. Retest the track-to-earth electrical resistance at the corrected locations, as specified.

F. Repair Procedures: The Contractor shall submit a repair procedure to the Engineer to assist in the future repair, removal and replacement of rails installed under this Contract. The procedure shall cover at least the following items:

1. Removal methods
2. Replacement Materials including source, shelf life and current cost
3. Bonding Methods
4. Welding Methods
5. Installation Methods

PART 4 – MEASUREMENT AND PAYMENT

- 4.1 Embedded Track TF (track feet) measurement will be along the center line of track stationing with horizontal pay limit within the 8-foot wide track slab limit and as indicated in the Contract drawings. There will be no separate measurement for 51R1 embedded track and block rail embedded track.

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SECTION 34 11 93.10

BOLTED RAIL JOINTS AND INSULATED RAIL JOINT

PART 1 - GENERAL

1.1 Description

- A. This Section includes specifications for furnishing, fabricating, and delivering bolted rail joints (standard bolted rail joint and compromise bars bolted rail joint) and insulated rail joints.

1.2 Reference Standards

- A. American Railway Engineering and Maintenance-of-Way Association, (AREMA):
 - 1. Manual for Railway Engineering, Vol. I, Chapter 4.
 - 2. Communications & Signals Manual of Recommended Practices
- B. ASTM International (formerly American Society for Testing and Materials - ASTM)
 - 1. A36 Standard Specification for Carbon Structural Steel
 - 2. A194 Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
 - 3. A325 Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
 - 4. F436 Standard Specification for Hardened Steel Washers
- C. The Society for Protective Coatings (formerly Steel Structures Painting Council), (SSPC):
 - 1. SSPC Painting Manual, Volume 1 Good Painting Practice

1.3 Submittals

- A. Submittals shall be as specified in Section 01 33 00 Submittals. The following submittals shall be made by the Contractor:
 - 1. Shop Drawings
 - 2. Procedures, including:
 - a) Installation procedures
 - b) Recommended bolt tensioning

- c) Proposed procedure for maintaining the specified gap in the CWR during installation of bonded joints.

- d) Proposed procedure for installing joints on embedded track construction.

3. Tests

- a) Test results of insulated rail joints

- b) Pre-qualification of crews

1.4 Quality Assurance

A. Certification

- 1. Tests certified by an approved testing laboratory.

- 2. Manufacturer's certification: Detailed description of the manufacturer's proposed quality control program for manufacturing the bonding adhesive used in the insulated rail joints, including how it is regulated, maintained, and monitored.

PART 2 - PRODUCTS

2.1 Materials

A. General

- 1. Standard bolted joint and insulated joint bars shall be minimum 24 inches long with four holes, shaped to fit 51R1 rail.

- 2. Compromise joint bars (51R1/115RE) shall be minimum 36 inches long with six holes, shaped to fit 51R1 in one end and to fit 115RE on the other end.

- 3. Hole locations shall be as shown in the AREMA Manual, Chapter 4 or as approved by the owner.

- 4. Bolt diameter shall be 7/8 inch.

- 5. Joint bars shall hold rail ends to within the straightness tolerances shown in the AREMA Manual, Chapter 4 for rail ends to be welded.

B. Insulated Rail Joints

- 1. Joint bars shall provide full face contact, conforming to web configuration of 51R1 rail and the Bonded Joint Clearance Envelope and fabricated from quenched carbon-steel as specified in the AREMA Manual for Railway Engineering, Chapter 4, "Specifications for Quenched Carbon Steel Joint Bars."

2. The fishing height of the joint bar shall be within a tolerance of plus or minus 1/64 inch of the dimensions indicated on the submitted and accepted Shop Drawings. The length of the joint bars shall be within plus or minus 1/8 inch of the dimension shown on the Shop Drawings. Portions of the joint bars adjacent to the rail shall be straight within a tolerance of plus or minus 1/32 inch.
3. The inside face of the joint bars shall have the insulating material pre-bonded to their face and shall be smooth with no stamping or branding.
4. Insulating materials shall be of high pressure and laminated design; shall be impervious to oil, grease, and water, and shall have electrical resistance characteristics equal to or greater than fiber insulation meeting the requirements of the AAR Manual, Part 8 and the Electrical Resistance Test specified herein. End posts shall not project below the base of the rail and shall be 3/16 inch thick.

Fasten insulated rail joints for 51R1 rail together with bolts that meet the chemical composition and mechanical property requirements of ASTM A325. The size of bolt holes shall be in accordance with the insulated rail joint manufacturer's recommendation.

5. Joint Components. Furnish insulated rail joints complete with bars, end posts, bushings, washers, bolts, collars, and adhesive as recommended by the manufacturer. Bolt tension shall be as specified by the manufacturer.
6. Acceptable Trade-names. Insulated Rail Joints shall be one of the following types or an approved equal:
 - a) The "Allegheny" joint as manufactured by the Allegheny Rail Products.
 - b) The "Portec Bond" toeless joint as manufactured by Portec Inc. Railway Products Division.
 - c) Trade-name joints named above must successfully pass electrical resistance testing as described in Section 2.2 C after installation in place is completed. Other tests as specified herein are not required for these joints.
 - d) Other brands will be considered as approved equal only if they successfully pass all the tests specified herein.
7. The adhesive shall have a shelf life of one year when stored in a location protected from the weather at a temperature which may vary from 40 degrees F to 90 degrees F.

C. Bolted Rail Joints

1. Bolted Rail Joints may be used at locations where field welding of joints is determined to be impractical.

2. Joint bars, shall provide full face contact, conforming to the web configuration of 51R1 and/or 115RE rail and fabricated from quenched carbon-steel as specified in the AREMA Manual for Railway Engineering, Chapter 4, "Specifications for Quenched Carbon Steel Joint Bars."
3. The fishing height of the joint bar shall be within a tolerance of plus or minus 1/64 inch of the dimensions indicated on the submitted and accepted Shop Drawings. The length of the joint bars shall be within plus or minus 1/8 inch of the dimension shown on the Shop Drawings. Portions of the joint bars adjacent to the rail shall be straight within a tolerance of plus or minus 1/32 inch.
4. Fasten bolted rail joints for 51R1 and/or 115RE rail together with bolts that meet the chemical composition and mechanical property requirements of ASTM A325. The size of bolt holes shall be in accordance with the bolted joint manufacturer's recommendation.
5. Joint Components. Furnish Bolted Rail Joints complete with bars, bushings, washers, bolts, collars, and epoxy adhesive as recommended by the manufacturer. Bolt tension shall be as specified by the manufacturer.

2.2 Qualification Testing of Bonded Joints

- A. Insulated Rail Joint Test Requirements: Three insulated rail joints shall be tested. Two shall be tested as specified in Article 2.2B. The remaining insulated rail joint shall be tested as specified in Article 2.2C and 2.2D. Testing shall not commence before Shop Drawings and installation procedures have been reviewed by the owner.
- B. Longitudinal Compression Test: Assemble two bonded joints in accordance with manufacturer's recommendations on two pieces of 51R1 Rail each 2 feet long. Saw the joint assembly in half at the end post. Perform the sawing in a manner that will prevent overheating, and damage to the epoxy bond. The cut shall be perpendicular to the centerline of the top of the rail with a tolerance of plus or minus one degree. Fabricate a device so that the reaction at the sawn end occurs only at the face of the joint bar when a load is applied at the centroid of the rail at the opposite end.
 1. Apply loads longitudinally in increments of 25,000 pounds. Maintain each load increment constant until the longitudinal deflection of the rail ceases before increasing the load to the next increment. Increase the load in these increments until a total load of 600,000 pounds is attained or failure occurs. Record at each increment of loading the load and differential movement of the rail and the joint bars, measured to 0.001 inch.
 2. Acceptance Criteria. At no time shall the bonded insulated rail joints show indication of slippage before a compressive load of 650,000 pounds is applied to the joint, nor shall the magnitude to the differential movement be more than 1/8 inch in any direction. At the completion of the test, after the load on the rail has been released, the relative position of rail and joint bar shall be within 1/8 inch of its original location. Failure of a joint to meet the above requirements shall be reason for rejection.
- C. Electrical Resistance Test. Fully assemble an insulated rail joint in accordance with manufacturer's recommendations on two lengths of 51R1 Rail, one 24 inches in length, the

other 42 inches in length, for an electrical resistance test. Support the rail on non-electrical conducting material. Acceptable trade-name joints should be installed and tested in-place.

1. With 500 volts dc applied to the rail on either side of the bonded insulated joint for a duration of three minutes, measure the actual current flow through the joint to the nearest 0.1 microampere and record.
 2. Acceptance Criteria: The minimum resistance for 500 volts dc shall be 10 megohms.
 3. Apply a potential of 50 volts ac to the rail on either side of the joint for a duration of three minutes for each increment of measurement for frequencies from 20 hertz to 10 kilohertz. Measure the impedance after three minutes with an accuracy of plus or minus 2 percent and record for each frequency.
 4. Acceptance Criteria: The minimum impedance for frequencies between 20 Hz and 10 KHz with 50 volts ac shall be 10,000 ohms.
- D. Dynamic Testing of Insulated Rail Joint: Subject the one bonded joint that has passed the electrical resistance test to dynamic testing. Support the test joint on 36-inch centers with the joint located between supports as shown in Figure 2. Apply repeated loads with two hydraulic rams. Apply loads to the rail alternatively at Points A and B. Vary each load from zero to 44,400 pounds in the approximate shape of a sine curve. Apply loads for two million cycles. Application of load at Point A and then at Point B shall constitute one cycle. Measure rail deflection every 500,000 load cycles at Point A and record to the nearest 0.001 inch.
1. Monitor loads with load cells placed between each ram and the railhead. Calibrate these load cells prior to commencement of the test program.
 2. Other methods of testing the joint dynamically may be submitted to the owner for review. The moment diagram envelope generated by other methods shall meet or exceed that specified in this Section.
 3. Acceptance Criteria: After 2,000,000 cycles, the insulated rail joint shall show no evidence of failure by bending. The deflection of the insulated rail joints shall not exceed 0.065 inch during the test.
 4. Repeat the electrical resistance test specified in Article 2.02C. The test results shall be within the acceptance criteria specified.
 5. After completion of the electrical resistance test, subject the joint assembly to the Longitudinal Compression Test as specified in Article 2.02B of this Section. Saw-cut the joint to adapt the section to the requirements stated in the test, with the acceptance criteria remaining the same as stated in the test.
 6. Acceptance Criteria: Should the joint assembly fail to meet the requirements of this Article, the insulated rail joint will not be accepted.

PART 3 - EXECUTION

3.1 Preparation of Rail Ends

- A. Holes shall be sized and located as shown in the AREMA Manual Chapter 4, Part 1, "Rail Drillings, Bar Punchings and Bolts".
- B. Holes shall be deburred.
- C. Rails other than high strength rails shall be end hardened as specified in Section General Track Construction Requirements.
- D. Rail ends shall be beveled as shown on AREMA Plan No. 1005.
- E. The end 21 inches of the web, bottom of head, and top of base of each rail shall be cleaned of foreign materials and loose rust and scale.
- F. For bonded and bolted joints, the cleaning shall be to near white metal in accordance with SSPC-SP-10 of the Steel Structures Painting Council (SSPC). Raised mill marking within the 21 inch distance shall be ground flush with the web.

3.2 Bonded and Bolted Joints

A. Crew Qualifications

- 1. The Supplier of insulated rail joints and bolted rail joints shall certify each crew and its foreman who will install the joints by training and/or through work experience in installing bonded and bolted joints. Previous bonded insulated joints and bolted joints fabricated by the crew and foreman from other projects should have more than 5 years performance history.
- 2. For insulated rail joint only: Resistivity test failure of installed insulated rail joint on this project disqualifies the foreman and at the discretion of the owner, the entire crew or any crew member. Assign a new foreman and crew personnel and repeat the qualification procedure.

B. Installation

- 1. Install joints at the locations shown on the Contract Drawings and as required by the signal and traction power systems. Ensure that the center of the joint is approximately centered between rail supports
- 2. Prepare rail ends as described in Article 3.1
- 3. Calibrate bolt-tightening equipment
- 4. Install joint in accordance with the manufacturer's instructions and the following:
 - a) Alternate directions of bolt insertion.
 - b) Ensure that there is no contact between joint bars and bolts and rail fasteners.

5. For insulated joint only. Test the resistivity across the insulating components of the insulated joint in accordance with Article 2.2C.

3.3 Measurement

- A. General: No Measurement will be made for standard bolted rail joints, compromise bar joints and Insulated Rail Joints. These items shall be considered incidental to Sections 34 11 23.33, and 34 11 29.10.
 1. Bolted rail joints will not be measured for payment as they are to be provided solely where the owner concurs that a welded rail joint is impractical. Since the rail weld would have been incidental to track construction, the substitute bolted rail joint will not be measured.

3.4 Payment

- A. General – No Payment will be made for bolted rail joints and bonded insulated joints. These items shall be considered incidental to Sections 34 11 23.33, and 34 11 29.10.

END OF SECTION

34 11 93.20

TRACK ELECTRICAL TESTING

PART 1: GENERAL

1.01 Description

- A. This Section includes specifications for testing trackwork to determine the track-to-earth resistance values and rail-to-rail resistance values of the running rails.
- B. The procedures presented in this Section are general guidelines for the measurement of track-to-earth resistance and rail-to-rail resistance as construction progresses. Modify these procedures to suit actual field conditions and the electrical networks established by the trackwork that results from continuing construction. It is the Contractor's responsibility to modify the procedures, with the approval of the Construction Manager, to suit actual conditions. Provide modifications of procedures at no additional cost to the owner.
- C. Final acceptance of tests for track-to-earth and rail-to-rail resistance values will be made by the Construction Manager subsequent to the completion of the in-progress tests specified in this Section.

1.02 Reference Standards

- A. American Society for Testing and Materials (ASTM)
 - ASTM G 165 Standard Practice for Determining Rail-to-Earth Resistance
- B. NACE International
 - 1. Standards for Testing

1.03 Submittals

- A. Refer to Section 01 33 00 – Submittals for submittal requirements and procedures.
- B. Testing company: Submit name and qualifications of testing company or agency to be used for this work. Include full background data of proposed company, including references to prior projects having requirements and/or complexities similar to this project. Include names and qualifications of senior engineering personnel to be used for field-testing and off-site review and analysis.
- C. Testing Plan
 - 1. Preliminary Approval: Submit a detailed testing plan, based upon the testing requirements included in this Specification. Include:
 - a) Measurement methodology in high resistance environments
 - b) Sample calculation formats

- c) Expected range of values for each test procedure
 - d) QA/QC procedures
 - e) Sample data sheet and spreadsheet file, showing the proposed format for test data documentation
2. Final Approval: The Construction Engineer will observe the initial field tests. Should the procedures appear valid after two separate tests, final approval will be given. The approved testing techniques may not be changed without written approval from the Construction Manager. Do not submit test results for non-approved test plans.
- D. Test Reports: Typed; 5 copies; submit within 14 days after completion of each test. Provide test data and calculations in a spreadsheet compatible with Microsoft Excel. Organize test data and calculations by track section tested. Include:
- 1. Weather, including temperature
 - 2. Track conditions
 - 3. Track configuration diagrams
 - 4. Verification of test data and calculations for accuracy by Contractor's QA/QC Corrosion Control Specialist
- E. Instruments: Submit list of instruments to be used. Include manufacturer, model number, serial number and calibration certificate for each instrument.

1.04 Witness

- A. Notify the Construction Manager 7 days prior to performing a test.
- B. The Construction Manager may witness testing.

1.05 Quality Assurance

- A. Use an approved testing company or agency.
- B. The testing company or agency proposed by the Contractor must be an independent firm regularly engaged in the field of track-to-earth resistance testing. The testing company or agency shall be staffed by NACE International (NACE) accredited Specialists who have been in responsible charge of work comparable in type and quality to that specified in this Section. The employees assigned to the project are to be personnel familiar with electrical testing procedures, electrical instruments, and general electrical networks.
- C. Personnel must be capable of modifying the procedures specified herein to suit actual field conditions should such modifications become necessary. The NACE Specialist must have at least 5 years of experience in construction acceptance testing.
- D. Perform testing in accordance with ASTM G 165 and Article 3 of this Section.

PART 2: PRODUCTS

2.01 Instrumentation

- A. Provide test instrumentation and associated equipment necessary to perform track-to-earth, and rail-to-rail tests, as outlined in the approved Testing Plan.
- B. Provide test instrumentation and associated equipment necessary to perform investigative testing to locate areas causing deficiencies in resistance values.
- C. Instruments shall have sufficient operating ranges, accuracy, and sensitivity to reduce measurement errors to less than 1 percent of the actual value.
- D. Voltmeters for track-to-earth voltage measurements shall have a minimum input impedance of 50 megohms.
- E. Calibration: Instruments shall show evidence of calibration within the twelve-month period preceding the date of actual use of instruments used to measure voltage and current.
- F. Maintain equipment in good working order.

PART 3: EXECUTION

3.01 Field Quality control

- A. Take a sufficient number of readings to ensure that human error in reading the instruments and transient disturbances in the electrical network have negligible influence on the final results.
- B. Obtain a minimum of three measurements for each data type test.
- C. Record time at which each reading is obtained.
- D. The number of readings taken to determine an electrical constant or property must be sufficient to assure that random factors due to human error in reading the instruments and transient disturbances in the electrical network have negligible influence on the final results. Record the time at which each reading is obtained. A sufficient number of measurements shall be made to ensure stability of results for each variable tested. The measurements shall be evaluated statistically to eliminate inconsistent data. Examine the data at the time of test to ascertain that removal of either the highest or the lowest value will not alter the arithmetic average of the group by more than five percent. If the average is altered by more than five percent, obtain additional sets of and combine the results with the first set. If the average of the combined data is still altered by more than five percent, by removal of the highest or lowest value, an unstable condition might exist. Advise owner of any unstable data condition.

3.02 Ground Contact Tests

- A. Conduct tests to locate electrical contacts to ground as scheduled in the Track Specification Section appropriate for the construction of the trackwork.
- B. Use a ground contact or fault location instrument specifically designed to locate coating or insulation flaws on buried structures. Provide equipment with receiver capable of quantitative display of signal strength. Audio tone receivers without a quantitative display are not permitted.
- C. Use appropriate grounding for the instrument signal generator for the length of track connected for the ground contact location.
- D. Prior to conducting ground contact testing, inspect the trackwork to ensure that inadvertent contacts to ground are not present. Clear all identified ground contacts prior to commencing the ground contact survey.
- E. Record the location and probable cause of all ground contacts located along with the weather and general site conditions at the time of the survey.
- F. Repair or replace defective trackwork components or construction methods causing ground contacts prior to conducting track-to-earth resistance tests on the track or rail segment.

3.03 Trackwork Electrical Tests

- A. Conduct track-to-earth resistance and rail-to-rail resistance tests for track increments as appropriate for the construction type of the track section tested.
- B. Perform electrical track-to-earth resistance and rail-to-rail resistance tests for all trackwork including special trackwork areas after track installation is completed within a construction segment. Do not defer testing. No more than 1,000 feet of track are to be in place for each track construction type, exclusive of special trackwork, before initial track-to-earth resistance testing is conducted. Subsequent test intervals shall be conducted upon the completion of a maximum of 2,500 feet of track.
- C. Prior to each test, visually examine the trackwork to ensure that there is no appreciable amount of debris, water, dirt, ballast or other conductive material in electrical contact with the track or track components. Record the condition of the track section to be tested on the data sheet.
- D. Notify the Construction Manager when the trackwork is ready for final acceptance testing. Submit all reports of electrical test procedures required by Article 3.04 before final acceptance testing. Provide access to the work site as required for the performance of the final acceptance testing by owner.

3.04 Electrical Test Procedures

- A. The purpose of this Article is to identify the minimum electrical test requirements for the track-to-earth and rail-to-rail resistance measurements. Conduct tests in accordance with

the test plan approved by owner. Testing agency shall modify the testing plan to suit varying field conditions and submit modifications to the Construction Manager for approval.

B. Electrically separated rail sections

1. Determine the effectiveness of any rail insulating joints (if applicable) at both ends of the track section by obtaining the effective resistance across the joints. Use either a DC current source and calculate the resistance utilizing the voltage difference across the joints created by a known test current or a resistance meter designed for use on buried facilities.
2. Establish a current circuit (I) between the rails and a low resistance ground electrode or suitable isolated low resistance ground. Use a current source able to operate during the test procedure without a drop in current of more than 10 percent of the value measured at the beginning of the test.
3. With the current circuit (I) closed, measure and record the current "on" values and the voltage between the rails and the grounding electrode.
4. Open the current circuit (I). Measure, and record the "off" values for both the current (I) and voltage of the rails to the grounding electrode.
5. Obtain a calibration of the rail resistance by passing a measured current through a finite span of rail and measuring the voltage drop across that finite span. Calculate the current flow factor, amperes/volt, for that finite span.
6. Use a separate rail contact for the voltage measuring circuit. Do not use the contact for the current circuit for voltage measurements. Measure and record the rail-to-earth voltages with the current circuit open and closed.
7. After completing Article 3.04B.5 above, measure and record the voltage drops across a short span of rail on either side of the tested rail section for use in calculating the rail current based on the rail calibration factor.
8. Repeat Articles 3.04B.6 and 3.04B.7 for the remainder of the tested track segment by incrementing the procedure from the beginning of the previously tested track segment. Maximum test intervals shall be as indicated in the appropriate Sections for track construction methods. Designate special trackwork as a separate intermediate interval. Other than for the first tested track segment, each tested track segment shall include an overlap of a minimum 200 feet of the portion of the previously tested track segment.
9. For initial track-to-earth resistance testing for an isolated construction type section and for sections of track not electrically connected to track outside of the test section that are shorter than the specified distance between test locations, Articles 3.04B.7 and 8 may be omitted and track-to-earth resistance values for that section computed from the results of Articles 3.04B.4 and 5 provided Article 3.04B.5 includes both ends of the isolated track section.

10. After completing the entire track segment test, re-measure and record the current "on" values and the voltage between the rails and the grounding electrode. Verify that the current is within 10 percent of the initial current value. If the test current varies more than 10 percent of the initial readings, modify the test procedure to include continuous monitoring of the test current.
 11. Calculate and record the resistance between the rails and the grounding electrode.
 12. Calculate the effective track-to-earth resistance of the overall tested segment.
 13. For test current (I) within the 10 percent tolerance value, divide the average change in rail-to-earth voltage caused by the test current (I) by the average value of the test current (I).
 14. For currents (I) outside of the 10 percent tolerance value, divide the rail-to-earth voltage change caused by a specific current by that current. Average the results of the individual track-to-earth resistance values.
 15. Calculate the track-to-earth resistance for each individual rail section in the tested track segment. The NACE Specialist shall evaluate the data for each individual track section to determine if the resistance of individual rail sections precludes an accurate measurement for that segment. If an individual rail section current flow cannot be reliably calculated, that section shall be combined with the next contiguous sections.
 16. Calculate the current flow into and from each rail section using the rail calibration factor and rail voltage drops measured at either end of the rail section and obtain the current gain or loss for that section.
 17. Divide the average rail-to-earth voltage change by the absolute value of current gain or loss to obtain the rail resistance to earth for each rail section.
 18. Present both the actual rail-to-earth resistance for each section and the rail section rail-to-earth resistance based on a theoretical 1,000-foot long section.
- C. Electrically continuous track sections with cross bonding in place.
1. Ensure electrical continuity between the rails within the track section tested by installing temporary wire connections between the rails at both ends of test section and at additional locations to maintain a maximum of 1,000 feet between connections.
 2. Determine the effectiveness of any rail insulating joints (if applicable) at both ends of the track section by obtaining the effective resistance across the joints. Use either a DC current source and calculate the resistance utilizing the voltage difference across the joints created by a known test current or a resistance meter designed for use on buried facilities.
 3. Establish a current circuit (I) between the rails and a low resistance ground electrode or suitable isolated low resistance ground. Use a current source able to operate during

the test procedure without a drop in current of more than 10 percent of the value measured at the beginning of the test.

4. With the current circuit (I) closed, measure and record the current "on" values and the voltage between the rails and the grounding electrode.
5. Open the current circuit (I). Measure, and record the "off" values for both the current and voltage between the rails and the grounding electrode.
6. Obtain a calibration of the rail resistance by passing a measured current through a finite span of rail and measuring the voltage drop across that finite span. Calculate the current flow factor, amperes/volt, for that finite span.
7. Establish a track-to-earth voltage measuring circuit at both ends of a tested track section, using a reference electrode in contact with the electrolyte near the rail. Use a separate rail contact for the voltage measuring circuit. Do not use the contact for the current circuit for voltage measurements. Measure and record the rail-to-earth voltages with the current circuit open and closed.
8. Measure and record the voltage drops across a short span of each rail on both sides of the tested track section for use in calculating the rail currents based on the rail calibration factor (Article 3.04C.6). Record the amount of test current (I) flow at the time of the individual track section tests.
9. Repeat Articles 3.04C.7 and 8 for the remainder of the tested track segment by incrementing the procedure from the beginning of the previously tested track segment. Designate special trackwork as a separate intermediate interval. Other than for the first tested track segment, each tested track segment shall include a minimum 200-foot long portion of the previous tested track segment.
10. After completing the entire track segment test, re-measure and record the current "on" values and the voltage between the rails and the grounding electrode. Verify that the current is within 10 percent of the initial current value. If the test current varies more than 10 percent of the initial readings, modify the test procedure to include continuous monitoring of the test current.
11. Calculate and record the resistance between the track and the grounding electrode.
12. Calculate the effective track-to-earth resistance of the overall tested segment.
13. For test current (I) within the 10 percent tolerance value, divide the average change in rail-to-earth voltage caused by the test current (I) by the average value of the test current (I).
14. For currents (I) outside of the 10 percent tolerance value, divide the rail-to-earth voltage change caused by a specific current by that current. Average the results of the individual track-to-earth resistance values.

15. Calculate the track-to-earth resistance for each individual section in the tested track segment. The NACE Specialist shall evaluate the data for each individual track section to determine if the resistance of individual rail sections precludes an accurate measurement for that segment. If an individual rail section current flow cannot be reliably calculated, that section shall be combined with the next contiguous sections
 16. Calculate the current flow into and from each rail in the track section using the rail calibration factor and rail voltage drops measured at either end of the track section and obtain the current gain or loss for that section.
 17. Divide the average track-to-earth voltage change by the absolute value of current gain or loss to obtain the track resistance to earth for each rail section.
 18. Present both the actual rail-to-earth resistance for each section and the rail section rail-to-earth resistance based on a theoretical 1,000-foot long section.
- D. Rail-to-Rail Resistance Test: For each track segment, perform rail-to-rail resistance tests on individual track segments, including special trackwork, forming track circuits and bounded by insulated rail joints. For test purposes, disconnect all made electrical connections to these track segments, except turnout fouling jumpers and other turnout and crossing bonds. Modify the following procedures as required based on actual field conditions:
1. Establish a current circuit between the two rails of the track segment under test, and a rail-to-rail voltage measuring circuit. Use rail contacts for the voltage measuring circuit separate from the rail contacts for the current circuit.
 2. With the current circuit closed, measure and record the current "on" values for current and voltage.
 3. Open the current circuit and measure and record the "off" values for the current and voltage.
 4. Calculate the effective rail-to-rail resistance by dividing the average change in voltage by the average change in current.
 5. Calculate the rail-to-rail resistance based on a 1000-foot section of single track.

3.05 Minimum Acceptable Resistance

A. Trackwork

1. Provide that any portion of the installed mainline direct fixation trackwork achieves calculated rail-to-earth resistance values of a minimum of 500 ohms calculated for a theoretical 1,000 feet of single track (two rails).
2. Provide that any portion of the installed mainline embedded trackwork achieves calculated track-to-earth resistance values of a minimum of 250 ohms calculated for a theoretical 1,000 feet of single track (two rails).

3. Provide that any portion of the installed Yard trackwork achieves calculated track-to-earth resistance values of a minimum of 75 ohms calculated for a theoretical 1,000 feet of single track (two rails).
 4. Provide that any portion of the installed mainline ballasted trackwork achieves track-to-earth resistance values of a minimum of 250 ohms calculated for a theoretical 1,000 feet of single track (two rails).
 5. Provide that any portion of the installed mainline trackwork achieves calculated rail-to-rail resistance values of a minimum of 200 ohms for a theoretical 1,000 feet of single track (two rails).
- B. If the test results show that a section of trackwork fails to meet the acceptance criteria, check all instrumentation setups; verify that the equipment is operating properly; inspect the section under test for installation deficiencies, and correct the problems detected. Repair trackwork and repeat tests until the resistance values satisfy the acceptance criteria. Perform remedial work and subsequent testing at no cost to owner.
 - C. If test results indicate a failure to meet acceptance criteria, notify the Construction Manager within two working days of the completion of the test.

3.06 Final Acceptance testing

- A. Notify the Construction Manager when the trackwork is ready for final acceptance testing.
- B. Submit Test Reports before final acceptance testing.
- C. Provide access to the work site as required for the performance of the final acceptance testing by the Construction Manager.

PART 4: MEASUREMENT AND PAYMENT

4.01 General

- A. Track Electrical Testing will not be measured for payment.
- B. All costs in connection herewith will not be paid for directly, but will be considered incidental to the item of work to which they pertain.

END OF SECTION

SPECIAL SPECIFICATION

EP-TWC

TRAIN TO WAYSIDE COMMUNICATIONS SYSTEMS

34 71.29.10



P. R. Bhakta, P.E.

1.00 Scope - This work consists of designing, furnishing, and installing Train to Wayside Communications (TWC) Systems and all wiring required to provide working TWC systems, as specified herein and in the Contract Drawings, at the locations shown on the Contract Drawings.

1.01 Functional Requirements by Location

The following is a description of the functional requirement for TWC at each loop location.

Oregon Street at Wyoming Avenue

Loop and Interrogator TWC-1

The new TWC loop located immediately south of the Oregon Street/Yandall Avenue intersection shall provide a call to the traffic signal at the intersection of Oregon Street with Wyoming Avenue whenever the lead cab of a train passes over the loop. This TWC call will result in the traffic signal at the Oregon Street/Wyoming Avenue intersection extending the existing through phase on Oregon Street until the lead cab of the train reaches loop TWC-2.

Loop and Interrogator TWC-2

Whenever the transponder of a train is over the new loop TWC-2 (located at the stopbar of the Oregon Street/Wyoming Avenue intersection), a call for Signal SC-1 and a preemption call to the traffic signal controller at the intersection of Oregon Street with Wyoming Avenue shall begin. The preemption sequence will begin immediately after completion of the normal Wyoming Avenue traffic signal phase. During the preemption sequence, the traffic signal controller shall provide a streetcar only phase (all-red at the intersection). Signal SC-1 will be programmed to provide the following displays:

- White Horizontal Aspect, indicating that the preemption sequence has not begun and the streetcar is not allowed to proceed.
- White Vertical Aspect, indicating that the preemption sequence has begun and the streetcar is allowed to proceed through the intersection.

Loop and Interrogator TWC-3

The new loop TWC-3, located within the intersection of Oregon Street and Wyoming Avenue, shall provide a cancel to the traffic controller for the previously called preemption whenever the transponder

in the cab transmits a checkout. Upon checkout, Signal SC-1 will return to a White Horizontal display.

Stanton Street at Franklin Avenue

Loop and Interrogator TWC-4

An operator of a Streetcar on Franklin Avenue will proceed through the Franklin Avenue/Mesa Street intersection until the front end of the streetcar is on TWC-4 (located mid-block) where the vehicles transponder can transmit a route code to TWC-4.

At this location, the Streetcar route code shall be preset to allow the vehicle to request a mainline track (primary route) to Franklin Avenue or a diverging track (secondary route) to Stanton Street from Franklin Avenue without additional operator input. Under a primary route call, the Streetcar will be allowed to proceed through the intersection during the next green phase on Franklin Avenue. Under a secondary route call, the streetcar will proceed to TWC 4a located at the intersection of Stanton Street with Franklin Avenue and wait there. Under either condition, the streetcar will proceed according to the Train signal SC-2. SC-2 will be programmed to provide the following displays:

- White Horizontal Aspect, indicating that - No route call to the signal system is present, or the switch points are not aligned or locked.
- White Vertical Aspect, indicating that - The streetcar is allowed to proceed and the switch points are aligned and locked for the primary route.
- White Diagonal Aspect, indicating that - The streetcar is allowed to proceed and the switch points are aligned and locked for the secondary route.

A blocking circuit will prevent the switch from moving while the streetcar is negotiating the switch. When the streetcar activates the blocking circuit, Train signal SC-2 will return to display the White Horizontal Aspect.

Loop and Interrogator TWC-4a

Whenever the transponder of a train is over the new loop TWC-4a (located at the stopbar of the Franklin Avenue/Stanton Street intersection), a call for Signal SC-2a and a preemption call to the traffic signal controller at the intersection of Franklin Avenue with Stanton Avenue shall begin. The preemption sequence will begin immediately after completion of the normal Stanton Street traffic signal phase. During the preemption sequence the traffic signal controller shall provide a streetcar only phase (all-red at the intersection), during the preemption sequence, Signal SC-2a will be programmed to provide the following displays:

- White Horizontal Aspect, indicating that the preemption sequence has not begun and the streetcar is not allowed to proceed.
- White Vertical Aspect, indicating that the preemption sequence has begun and the switch points are aligned and locked for the primary route.
- White Diagonal Aspect, indicating that - The streetcar is allowed to proceed and the switch points are aligned and locked for the secondary route.

Under normal traffic signal operations at the Franklin Avenue/Stanton Street intersection or a primary

route movement by the streetcar, Signal SC-2a will mirror the operations of the traffic signal and display a white vertical aspect while the traffic signal is green on Franklin Avenue and display a white horizontal aspect while the traffic signal is red on Franklin Avenue.

Loop and Interrogator TWC-5

The new TWC loop TWC-5, located within the intersection of Stanton Street and Franklin Avenue, shall provide a cancel to the traffic controller for the previously called preemption whenever the transponder in the cab transmits a checkout. Upon checkout, Signal SC-2a will return to a White Horizontal display. Note that if the streetcar is making a secondary route movement, no additional input will be accepted at loop TWC-4 until checkout occurs.

4th Avenue at Santa Fe Street

Loop and Interrogator TWC-6

Whenever the transponder of a train is over the new loop TWC-6 (located at the stopbar of the Santa Fe/4th Avenue intersection), a call for Signal SC-3 and a preemption call to the traffic signal controller at the intersection of Santa Fe Street with 4th Avenue and the turnout to the maintenance facility shall begin.

At this location (TWC-6), the Streetcar route code shall be preset to allow the vehicle to request a mainline track (primary route) to Santa Fe Street. A call for a diverging track (secondary route) to the maintenance facility from Santa Fe Street can be made using the CALL pushbutton and a valid track route code on the TWC control head mounded on the operator's console. Under either a primary route or a secondary route call, the streetcar will proceed through the intersection during an all-red phase at the intersection which will occur after completion of the normal 4th Avenue traffic signal phase. Under either condition, the train will proceed according to the Train signal SC-3. SC-3 will be programmed to provide the following displays:

- White Horizontal Aspect, indicating that - No route call to the signal system is present, or the switch points are not aligned or locked.
- White Vertical Aspect, indicating that - The streetcar is allowed to proceed and the switch points are aligned and locked for the primary route.
- White Diagonal Aspect, indicating that - The streetcar is allowed to proceed and the switch points are aligned and locked for the secondary route.

Loop and Interrogator TWC-7

The new loop TWC-7, located within the intersection of Santa-Fe Street and 4th Avenue, shall provide a cancel to the traffic controller for the previously called preemption whenever the transponder in the cab transmits a checkout. Upon checkout, Signal SC-3 will return to a White Horizontal aspect.

Loop and Interrogator TWC-8

The new loop TWC-8, located within the intersection of Santa-Fe Street and 3rd Avenue, shall provide a call to the rail controller to return the switch on Santa-Fe Street between 3rd and 4th Streets back to the primary route position whenever the transponder in the cab transmits a checkout.

A blocking circuit will prevent the switch from moving while the streetcar is negotiating the switch. When the streetcar activates the blocking circuit, Train Signal SC-3 will return to display the White Horizontal Aspect.

Santa Fe Street at Overland Avenue

Loop and Interrogator TWC-9

The new loop TWC-9, located immediately north of the Santa Fe Street/Paisano Drive intersection shall provide a call to the traffic signal at the intersection of Santa Fe Street with Overland Avenue whenever the lead cab of a train passes over the loop. This TWC call will result in the traffic signal at the Santa Fe Street/Overland Avenue intersection extending the existing through phase on Santa Fe Street until the lead cab of the train reaches loop TWC-10.

Loop and Interrogator TWC-10

Whenever the transponder of a train is over the new loop TWC-10 (located at the stopbar of the Santa Fe Street/Overland Avenue intersection), a call for Signal SC-4 and a preemption call to the traffic signal controller at the intersection of Santa Fe Street with Overland Avenue shall begin. The preemption sequence will begin immediately after completion of the normal Overland Avenue traffic signal phase. During the preemption sequence, the traffic signal controller shall provide a streetcar only phase (all-red at the intersection) Signal SC-4 will be programmed to provide the following displays:

- White Horizontal Aspect, indicating that the preemption sequence has not begun and the streetcar is not allowed to proceed.
- White Vertical Aspect, indicating that the preemption sequence has begun and the streetcar is allowed to proceed through the intersection.

Loop and Interrogator TWC-11

The new loop TWC-11, located within the intersection of Santa-Fe Street and Overland Avenue, shall provide a cancel to the traffic controller for the previously called preemption whenever the transponder in the cab transmits a checkout. Upon checkout, Signal SC-4 will return to a White Horizontal display.

Stanton Street at Baltimore Drive

Loop and Interrogator TWC-12

The new loop TWC-12, located immediately north of the Stanton Street/Cincinnati Drive intersection shall provide a call to the traffic signal at the intersection of Stanton Street with Baltimore Drive whenever the lead cab of a train passes over the loop. This TWC call will result in the traffic signal at the Stanton Street/Baltimore Drive intersection extending the existing through phase on Stanton Street until the lead cab of the train reaches loop TWC-13.

Loop and Interrogator TWC-13

Whenever the transponder of a train is over the new loop TWC-13 (located at the stopbar of the Stanton Street/Baltimore Drive intersection), a call for Signal SC-5 and a preemption call to the traffic signal controller at the intersection of Stanton Street with Baltimore Drive shall begin. The preemption sequence will begin immediately after completion of the normal Baltimore Drive traffic signal phase. During the preemption sequence, the traffic signal controller shall provide a streetcar only phase (all-red at the intersection), while Signal SC-5 provides an indication allowing the train to proceed through the intersection. Signal SC-5 will be programmed to provide the following displays:

- White Horizontal Aspect, indicating that the preemption sequence has not begun and the streetcar is not allowed to proceed.
- White Vertical Aspect, indicating that the preemption sequence has begun and the streetcar is allowed to proceed through the intersection.

Loop and Interrogator TWC-14

The new loop TWC-14, located within the intersection of Stanton Street and Baltimore Drive, shall provide a cancel to the traffic controller for the previously called preemption whenever the transponder in the cab transmits a checkout. Upon checkout, Signal SC-5 will return to a White Horizontal display.

1.02 Submittals

Submit the following items in accordance with these specifications

A. Shop drawings for the following items:

1. Each TWC interrogator, showing the functions performed by the interrogator and the model numbers and the location of every electronic rack, electronic circuit card, and power supply.
2. Layout drawings of each interrogator cabinet showing, the location of all equipment in the cabinet and the cabinet's method of attachment in the signal case.

B. Product data for the following items:

1. TWC interrogators
2. Interrogator lead cable
3. Traffic signal controller cable
4. Power connection cable
5. TWC loop wire
6. TWC cabinets
7. TWC cabinet heaters
8. Tuning filters, if required
9. Loop joint sealant
10. Loop sealant backer rod

11. Blocking circuits and associated equipment

C. Operations and Maintenance Manuals. These manuals shall include:

1. The as-installed and tested configuration of each TWC interrogator, showing the functions performed by the interrogator and model numbers and location of every electronic rack, electronic circuit card, and power supply.
2. As-installed layout drawings of each interrogator cabinet showing the location of all equipment in the cabinet.
3. The as-installed location and size of each TWC loop and blocking circuit.
4. A description of the TWC system and a description of each and printed circuit card and/or electronic module complete with part numbers, theory of operation, and test requirements.
5. Installation and test procedures for the TWC system and loop tuning procedures.
6. 10 copies of each manual shall be submitted.

Materials

1.10 General

The Streetcar system shall be equipped with a Train-to-Wayside communications system. The streetcars shall be equipped with TWC transponders mounted on the front end of the car body, between the front bumper and front truck. The TWC system shall use a wayside interrogator to excite a wayside loop antenna with approximately 0.1 A, at frequencies between 80 kHz and 120 kHz.

The TWC wayside loop antennas located between the rails are installed in figure 8 patterns to minimize the affect of streetcar propulsion currents. The current in each wayside TWC loop generates an electromagnetic field which is detected by the car-carried TWC transponder located on each streetcar. Upon receipt of the wayside TWC interrogation signal, the car-carried transponder transmits a 19-bit data message back to the wayside loop. The transmission from the car-carried transponder is also between 80 kHz and 120 kHz.

The Contractor shall furnish and install the wayside portion of the TWC system in accordance with the requirements described in this Section. The wayside TWC equipment to be furnished and installed shall consist of the following:

- A. TWC Loops and blocking circuits installed in the pavement, between the rails, at locations shown on the Contract Drawings.
- B. Unless otherwise noted, interrogators will be located in the traffic signal controller cabinet of the impacted intersection to control loop(s).
- C. Interrogator leads connecting the loops and blocking circuits to the interrogator, including all additional cabling, filters, tuning devices, and junction boxes necessary to accomplish the function requirements described herein and shown in the Contract Drawings.
- D. Traffic signal controller leads, and power supply connections, as indicated on the Contract Drawings.

E. Operations and Maintenance Manuals.

1.11 TWC Data Requirements

The contractor shall furnish and install wayside TWC equipment to provide for the accurate reception and processing of 19-bit data message from the car based transponders. The Contractor shall provide the wayside interrogators capable of processing the information from the streetcars via the wayside loop antennas in the format depicted in Table 1 (Sample Truth Table) below.

1.12 Loop Antennas (TWC Loops) and Blocking Circuits

The loop antenna TWC Loops) shall consist of one turn of AWG #12 XHHW polyethylene jacketed traffic signal loop wire.

In order to mitigate the effects of inductive coupling between the current in the rails and the loop, each loop shall be installed in a figure "8" pattern.

Loops dimensions are shown in the Traffic Signal Plans.

The loop shall be connected to the TWC interrogator by the interrogator lead and loop connecting unit, as described below.

The contractor shall be responsible for both design and installation of the Blocking Circuits. Blocking Circuits shall be installed and connected to the switch control cabinets per manufacturer's recommendations.

TABLE 1
DATA CODE FORMAT (SAMPLE TRUTH TABLE)

	TRANSPONDER DATA BIT -																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Binary Weight		1	2	4	8	16	32	64			1	2	4	8	16	32			64
Lead Cab	L	R	R	R	R	R	R	R	P	C A N	T	T	T	T	T	T	S	S	T
Logic Level	1	X	X	X	X	X	X	X			X	X	X	X	X	X			X
Right																		1	
Left																	1		
Pre-empt ("Call")									1										
Cancel										1									

TRAIN/WAYSIDE COMMUNICATION SYSTEM LEGEND

AA	=	Binary 128
BB	=	Binary 256
CC	=	Binary 512
C=	=	Car Number (0 through 99)
E	=	End-of-Train (Signal from Tail Lamps)
L	=	Lead Cab (Front End)
NL	=	Non-Lead Cab (Intermediate Cab or Trailing Cab)
P	=	Preempt or "CALL"
CAN	=	Cancel
R=	=	Route Number (0 through 99)
S	=	Track Switch Control (Left or Right)
SP	=	Spare
T	=	Train Number (00 through 99)
X	=	High or Low Logic Level (Left LSB, Right MSB)
1	=	High Logic Level
0	=	Low Logic Level

1.13 Interrogators

The interrogator includes all of the wayside control equipment necessary to query a transponder, and to successfully receive and decode the data messages from that transponder. The interrogator also includes all of the interface circuitry, raceway, and cabling necessary to meet the functional requirements described herein and shown on the Contract Drawings.

The interrogator shall:

- A. Transmit a 30 kHz. to 100 kHz. signal via the loop antenna, to, activate any transponders within the range of that loop antenna. The transmitted signal shall be a burst of 30 kHz. to 100 kHz. RF energy, lasting for a few milliseconds. This tone burst shall be repeated once every 25 to 100 milliseconds.
- B. Receive data messages from the transponder if a transponder is in range of the loop.
- C. Check the received data messages for the presence of a proper start code and a stop code.
- D. Provide for the comparison between two successive data messages and validation only after they have been found to be identical. If the data message meets the requirements, a strobe signal shall be generated which shall enable transfer of the data to an output buffer.
- E. Provide for the data from the output buffer to be transmitted to application circuit cards. These cards shall provide relay contact closure(s) enabling the appropriate traffic signal controller and track switch control equipment to act upon the message transmitted from the train. The particular application outputs required vary with location and are shown in the Contract Drawings, and described herein.
- F. Provide for future changes in route codes and streetcar operating philosophy, by being capable of being re-configured so as to respond differently to different route codes through only the removal/addition of diodes in the decoder circuitry.

The wayside interrogator shall be modular in nature and manufactured to fit on a standard 19" rack configuration. All electronic circuitry, with the exception of the power supply, shall be on removable printed-circuit cards.

The design of the interrogator shall allow the placement of loop antennae anywhere from 0 to 1350 feet from the interrogator rack.

Interrogator output relay contacts shall be rated for 0-24 VDC at 0-0.2 amperes and 125 VAC at 0-0.2 amperes.

1.14 Interrogator Power Supplies

Each interrogator shall include its own integral power supply(s). The Contractor shall furnish and install all cabling, raceway, protective devices, and coordination necessary with the Engineer, the City of El Paso, and the utility as appropriate to power this equipment. Supplied power will be commercial, single phase 120 VAC.

1.15 Expandability

The basic functional requirements for the TWC system at this time involve providing outputs for calling routes. However, the TWC equipment must also be capable of being expanded to include

additional outputs. Each interrogator rack must contain sufficient backplane wiring, power supply capacity, and two spare printed-circuit board sockets to allow for additional buffered relay outputs to call additional routes, or traffic light pre-emption requests.

In the event that an interrogator rack controls more than one loop antenna, that interrogator rack shall contain sufficient capacity to provide three additional outputs, described above, for each loop.

1.16 Interrogator and Traffic Signal Controller Leads

The interrogator lead and the loop connecting unit shall extend from the loop antenna to the interrogator. It shall be constructed in accordance with manufacturer's recommendations, and shall include any necessary amplifiers, tuning devices, filters, and junction boxes.

All cabling used in the traffic signal controller and power supply connection leads shall be suitable for direct burial in wet and dry application, and designed for a 30 year life in that application. Conductors shall be #14 AWG minimum. All cable used in the interrogator and power supply connection leads shall be submitted to and approved by the Engineer. Lead cable shall be in a shielded, twisted pair cable, with a polyethylene overall outer jacket.

Interrogator lead cable shall be AWG #14 (minimum), polyethylene insulated copper conductors suitable for direct burial in wet and dry application, and designed for a 30-year life in that application. Interrogator lead cable shall be continuous from interrogator terminal strip to the loop connecting unit. All cable purchased for use as interrogator lead cable shall be submitted to the Engineer for approval.

1.17 TWC Loop Joint Sealant

The TWC loop joints shall be sealed using back-up rods and sealant. The sealant shall be Edco 2094 Loop Epoxy Sealant with a uniform gray color or an approved equal. The backer shall be compressible polyethylene foam, polyethylene jacketed polyurethane foam, butyl rubber foam, neoprene foam, or other flexible, permanent, non-absorptive material and shall be recommended for compatibility with the sealant by the sealant manufacturer.

1.18 Listing and Labeling

Electrical equipment and material shall be listed and labeled for the purpose for which it is used by Underwriters Laboratories, Factory Mutual, CSA, ETL or equivalent nationally recognized testing laboratory.

Those materials or assemblies that do not bear an independent testing label shall meet the special approval criteria established by the State and local electrical codes.

Construction

1.40- TWC Interrogator Installation

Each interrogator shall be installed in the signal case in its cabinet, at the locations shown in the Contract Drawings.

The Contractor shall prepare and submit shop drawings for each location, detailing the cabinet size, mounting detail and location, electrical and grounding connections to be used and bill of materials for the Engineer approval.

The Contractor shall perform all work required to make the power supply connection, including, as required, addition of breakers, raceway, and rearrangement of existing connections.

The cabinet shall be primed and painted as specified on the Contract Drawings.

1.41 Interrogator, Power Supply, and Traffic Signal Controller Lead Installation

All cables shall run continuously without splicing from termination point to termination point. The Contractor shall carefully determine the length of cable necessary to reach from termination point to termination point. Splicing of cable at any location other than those shown on the Drawings is not permitted. Splicing of cable in raceway, pullboxes, junction boxes and underground vaults, manholes and handholes is not permitted.

Cable shall not be pulled through any intermediate junction box, pullbox, vault, manhole, handhole or any other opening in the raceway or duct, unless specifically required by the Engineer. The necessary length of cable to be installed will be pulled from one junction box, pullbox, vault, manhole, handhole, or traffic signal controller cabinet to next junction box or manhole and the immediate length of cable to be installed in the next raceway or duct shall be carefully stored in a manner that will allow that length of cable to be safely pulled into the next raceway or duct. The Contractor's proposed storing methods shall be subject to approval by the Engineer.

At all termination points, any cable that is not immediately terminated shall be sealed with an approved end cap to prevent moisture or dirt from entering the cable end. Tape shall not be permitted to seal the cable end. The cable end shall remain sealed until termination takes place. Cables that are not immediately terminated shall have 3 feet of slack. Slack is defined as the length of cable extending out of the cabinet opening when the cable is held straight outward.

1.42 TWC/Signal System Integration

The Contractor shall provide systems integration and testing in accordance with City approved test plans and procedures, with accompanying check lists and test witness sign off sheets. The City of El Paso traffic signal system is comprised of 170 type controllers running Bi Tran Systems QuicNet Pro 233 RV2 software.

- A. Signal System integration tests shall be conducted and performed by the Contractor upon completion of all required system interconnections.
- B. After completion of the Contractor provided system integration testing, the Contractor, with City support, will perform a complete System Integration Test prior to pre-revenue service operations. The Contractor shall also:
 - Assist City personnel with troubleshooting of field problems and provide continued education about the Signal System equipment during this period.

- Correct any problems encountered during systems integration testing at no cost to the City.
- Submit all field test data to the City Engineers for review and approval.

C. The final phase of the contract shall be to provide technical support to the City after the streetcar system has been placed into revenue service. The Contractor shall provide on-call maintenance support to the City for issues that may be beyond the expertise of the City maintenance staff.

D. Upon successful completion of System Integration Tests, the integrated system shall be phased over for City use. The Commissioning process, once completed, shall be coincident with the City's acceptance of the materials, equipment, goods and services provided by the Contractor. The Contractor shall prepare a system checklist, delineating all work performed including design approvals, test completion reports, as-built drawings and manuals, spare parts records, training reports, and related materials reflecting the status of the entire signal system.

1.43 Turn-On Procedure

Upon completion of all TWC work at a specific location, the Contractor shall notify the Engineer that the installation is ready for turn-on. Following such notification, and upon completion of all other associated work by the City, the City shall schedule turn-on for each intersection.

Representatives of both installation Contractor and TWC and related equipment manufacturers shall be in attendance at each turn-on.

Training Program

1.50 Training Program

The Contractor shall develop a training program for the City's maintenance and engineering personnel, technicians, supervisors and management personnel. The program shall include, but not be limited to:

- Performance objectives that state the expected behavior, the conditions under which performance will occur, and the measures and standards to be applied.
- Lesson plans, including the sequence of activities, an outline of context and a summary of learning strategies to be used (e.g., classroom presentation, hands-on practice, audio/video presentation, etc.).
- Methods and criteria for evaluating performance, including an objective grading system to report progress of trainees, Grading shall be kept confidential and furnished only to personnel designated by the City.
- Resources required, such as equipment and shop space.
- A schedule for delivery of training courses to all designated personnel from the City. The size and location for the training must be approved in advance by the City.

1.51 Training Materials

Provide materials to support the training courses, including: instruction guide, training aids, student workbooks, and operation and maintenance manuals.

- A. Instructor Guide: Provide instructor guides containing: course outline, agendas, objectives, lesson plans, training aids, presentation guidelines, suggested discussion questions, and criteria for measuring student performance.
- B. Training Aids: Provide training aids such as mock-ups, scale models, and overhead transparencies or Power Point slides. All training aids shall be of durable construction and shall become the property of the City. Verify that any equipment or tools used during training are in good working condition both before and after the training sessions.
- C. Student Workbooks: Provide student workbooks that include course objectives, a course agenda, schedule of sessions, copies of overhead transparencies, lecture outlines and any additional printed material used during the course.

1.52 Class Lectures/Presentations

Provide experienced trainers who are knowledgeable about the subject matter. Trainers must be able to answer questions and give detailed explanations and demonstrations. All presentations shall be made in English.

- A. Operational training shall be provided in the following areas:
 - Communication equipment operation.
 - Test equipment operation.
- B. General maintenance and repair training shall be provided for Communications Equipment.
- C. The Contractor shall designate the total number of hours allocated for training of each work group listed below: the minimum shall not be less than:
 - Eight (8) hours for management personnel/supervisors. The maximum class size shall be up to six (6) people.
 - 24 hours for maintenance and engineering personnel and technicians for a class size of up to five (10) people.
 - Eight (8) hours for operation personnel with a maximum class size of up to 10 people.

Measurement and Payment

1.60 Measurement

No separate measurement will be made of the Work specified in this section.

1.61 Payment

Work specified in this section is incidental to Work described in other sections.

END OF SECTION

SPECIAL SPECIFICATION

EP-SYSTEMS

Systems

1. **Description.** Construct the Overhead Contact System (OCS) and Traction Power Substations (TPSS) for the El Paso Streetcar Project in El Paso, Texas, as shown on the plans and the attached specifications. Perform Baseline and Revenue Stray Current Testing, as described in the attached specifications.
2. **Materials.** All materials furnished and all construction methods utilized will be in accordance with the plans, details, and attached specifications.
3. **Measurement.** The Overhead Contact System will be measured by the lump sum. The OCS spare parts as indicated in the attached specifications will be measured by the lump sum. The Traction Power Substations will be measured by each substation complete in place. The TPSS spare parts indicated in the attached specifications will be measured by the lump sum.
4. **Payment.**
 - a. **Traction Power Substation.** The work performed and materials furnished in accordance with this item and measured as provided for under "Measurement" will be paid at the unit price bid for "TPSS" for the locations specified ("A1", "A2", "A3", "A4", "S1") and "TPSS – Spare Parts". This price will be full compensation for furnishing all materials, equipment, labor, and incidentals necessary to complete the work specified in the attached specifications (listed under Section 5 "Attached Specifications") and plans.

The following items related to the civil work related to the traction power substations will be paid for separately as indicated elsewhere in the project documents and as follows:

Foundations:	TxDOT Item 420 "Concrete Structures"
Removals:	TxDOT Item 104 "Removing Concrete"
	TxDOT Item 105 "Removing Stabilized Base and Asphalt Pavement"
Sidewalk:	TxDOT Item 531 "Sidewalk"
Curb:	TxDOT Item 529 "Concrete Curb, Gutter, and Combined Curb and Gutter"
Boring of the feeder duct under Mesa Street:	
	TxDOT Item 476 "Jacking, Boring, or Tunneling Pipe or Box"
Perimeter Fence:	Item EP-IRON FENCE "Installation of Wrought Iron Fence and Gates at TPSS"

- b. **Overhead Contact System.** The work performed and materials furnished in accordance with the Overhead Contact System and measured as provided for under "Measurement" will be paid at the unit price bid for "OCS System – Complete in Place"

and “OCS System – Spare Parts”. This price will be full compensation for furnishing all materials, equipment, labor, and incidentals necessary to complete the work specified in the attached specifications (listed under Section 5 “Attached Specifications”) and plans.

The lump sum payment for “OCS System – Complete in Place” shall be based on the installation of plain OCS tubular steel poles in accordance with Section 34 23 37 “OCS Tubular Steel Poles”. The lump sum payment for “OCS System – Complete in Place” shall not include Ornamental Poles as specified in the plans and in Section 34 23 37.11 “OCS Pole Ornamentation”. The incremental cost for the Ornamental Poles as shown in the plans shall be paid for separately.

The following items associated with the OCS poles will be paid for separately as follows:

Foundations: TxDOT Item 416 “Drilled Shaft Foundations” (Also refer to 34 23 71 OCS Pole Foundations for additional requirements)
Banner Arms: Item EP-ARM “Banner Arm Assembly”
LED Lighting Fixtures: Item EP-LUMINAIRE “Special Illumination”
Incremental Cost for the Ornamental Poles

- c. **Baseline and Revenue Stray Current Testing.** The work associated with the baseline and revenue stray current testing will not be paid for separately but considered subsidiary to the pertinent bid items.

5. Attached Specifications.

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01 33 00 Submittal Procedures
01 42 00 References
01 43 00 Systems Quality Assurance
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DIVISION 05 METALS

05 05 00 Common Work Results for Metals

DIVISION 09 FINISHES

09 67 25 Dielectric Epoxy Flooring

DIVISION 22 PLUMBING

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DIVISION 26 ELECTRICAL

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26 05 10 Common Work Results for Systems Conductors and Cable
26 05 19 Low-Voltage Conductors and Cable
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DIVISION 34 TRACTION POWER

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34 21 05 Common Work Results for Traction Electrification System (TES)
34 21 16 TPSS Enclosures
34 21 19 DC Switchgear
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34 21 25 TPSS DC Control Power
34 21 31 Substation Automation System (SAS)
34 21 33 Rail-Voltage Monitoring and Grounding System
34 21 40 DC Disconnect Switches
34 21 46 Traction Power DC Contactor Panel
34 21 50 DC Surge Arresters
34 21 73 TE System Studies
34 21 80 TES Spare Parts and Special Tools
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OVERHEAD CONTACT SYSTEM

DIVISION 34.23 OCS OVERHEAD TRACTION POWER

34 23 10 OCS Description and General Requirements
34 23 11.01 OCS Glossary of Standard Terms
34 23 35.99 OCS Pole Painting
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34 23 37.11 OCS Pole Ornamentation (See payment clause above)
34 23 40 OCS Wire and Cable
34 23 50 OCS Assemblies, Components and Fittings
34 23 64 OCS Special Tools
34 23 66 OCS Spare Parts
34 23 70 OCS Installation
34 23 71 OCS Pole Foundations
34 23 72 OCS Tubular Pole Installation
34 23 77 OCS Surge Arrester Installation
34 23 78 OCS Disconnect Switch Installation
34 23 80 OCS Testing
34 23 90 OCS Installation Records
34 23 96 OCS Installation and Maintenance Manuals
34 23 97 OCS Maintenance Staff Training

BASELINE AND REVENUE STRAY CURRENT TESTING

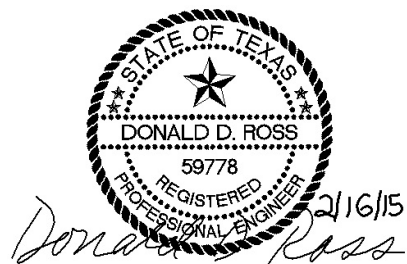
26 24 90 Baseline and Revenue Stray Current Testing

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DIVISION 05

METALS

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DIVISION 09

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LTK Engineering Services
TBPE Registration No. F-1389

Technical Specification

SECTION 01 11 00 SUMMARY OF SYSTEMS WORK

PART 1 - GENERAL

1.1 SUMMARY

- A. Section applies to Systems Work, which is found in Specification Sections in Divisions 5, 9, 22, 26, and 34.
- A. Traction power substations general requirements.
- B. Overhead contact system (OCS) general requirements.

1.2 PREPACKAGED 350KW TRACTION POWER SUBSTATIONS

- A. Provide four prepackaged 350kW substations, set in place, ground, and connect to utility power.
- B. Test and energize substations.
- C. Test substations and OCS with each other and with streetcars.

1.3 BUILT-IN-PLACE MSF 150KW TRACTION POWER SUBSTATION

- A. Provide 150kW substation equipment and all other materials and equipment required for a complete substation.
- B. Connect MSF substation to Shop OCS.
- C. Test and energize substation and OCS.
- D. Provide and test interlocking.

1.4 OVERHEAD CONTACT SYSTEM

- A. Perform design completion for a complete overhead contact system (OCS). See Section 34 23 10, OCS Description and General Requirements.
- B. Provide complete single contact wire OCS, including procurement, delivery, installation, and testing of OCS from interface with traction power substation positive feeders to interface with rail vehicle pantograph.
- C. Provide all OCS design, installation, and testing documentation as required in the OCS Specifications.
- D. Provide special tools, training, instruction manuals, and maintenance manuals for OCS operation, as required in the OCS Specifications.

1.5 DC FEEDERS

- A. Provide dc positive feeders and dc negative returns from traction power substations to OCS and to rail. See Sections 26 05 10, Common Work Results for Conductors and Cable and 26 05 19, Low-Voltage Conductors and Cable and Contract Drawings.
- B. Provide crossbonds and rail bonds as a part of the dc negative return system. See Sections 26 05 10, Common Work Results for Conductors and Cable and 26 05 19, Low-Voltage Conductors and Cable and Contract Drawings.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 01 31 19 PROJECT MEETINGS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section applies to Systems Work, which is found in Specification Sections in Divisions 5, 9, 26, and 34.
- B. Additions to meeting requirements found elsewhere in the Contract Documents:
 - 1. Design conferences.
 - 2. Systems weekly progress meetings.
 - 3. Other special meetings.

1.2 DESIGN CONFERENCES

- A. Dates for design conferences will be as mutually agreed by Owner, Engineer, and Contractor.
- B. Traction power substation design conference will be held in El Paso within 45 days of NTP. Contractor and subcontractor design personnel are required to attend. The following will be discussed:
 - 1. Basic TPSS layouts.
 - 2. One-line diagram.
 - 3. Proposed basic TPSS parts.
 - 4. Proposed sequence of TPSS work.
 - 5. Design, production and field testing procedures.
 - 6. Submittal list.
- C. Overhead contact system (OCS) design conference will be held in El Paso within 45 days of NTP. Contractor and subcontractor design personnel are required to attend. The following will be discussed:
 - 1. Proposed assembly and arrangement drawings that demonstrate overall understanding of Project OCS design requirements.
 - 2. Samples of OCS layouts.
 - 3. Samples of design calculations.
 - 4. Demonstration of how pantograph clearance has been considered in hardware and OCS arrangement design.
 - 5. Proposed OCS hardware.
 - 6. Proposed sequence of OCS Work.
 - 7. Proposed schedule of work, including design completion, installation, and testing.
 - 8. Safety, security, and theft prevention.

9. Quality assurance.
10. Mobilization and staging.
11. Coordination of work with Owner and interested parties.
12. Submittal list.

1.3 WEEKLY PROGRESS MEETINGS

- A. Progress meetings will be scheduled by the Engineer no more than once each week during the period of performance of the Contract.
- B. Inform all participants and interested parties of date and time, of meeting at least 7 days in advance.
- C. Contractor shall provide a conference call in number.
- D. Include representatives of Subcontractors who are or will be performing work during the current and following month in the progress meetings.
- E. Distribute notices of these meetings before such meetings to Subcontractors.
- F. Prepare agenda for construction progress meetings a minimum of 24 hours prior to the meeting and e-mail to the Engineer for review. It will generally include the following:
 1. Discussion of the status of the Critical Path activities, including submittals. Discussion of methods intended to bring late activities back on schedule.
 2. Discussion of design issues.
 3. Discussion of status of RFIs and submittals.
- G. Prepare meeting minutes within 3 days following the meeting and e-mail draft to meeting attendees for review. Make corrections and transmit final minutes before the next meeting. Submit initial meeting minutes format to the Engineer for approval.

1.4 SPECIAL MEETINGS

- A. Special meetings will be scheduled and conducted by the Engineer throughout the project as the Engineer deems necessary.
- B. Meetings may be called by the Engineer or Contractor to discuss submittals.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 01 32 13 SCHEDULING OF WORK

PART 1 - GENERAL

1.1 SUMMARY

- A. Section applies to Systems Work, which is found in Specification Sections in Divisions 5, 9, 26, and 34.
- B. Requirements for the preparation, revision, and submittal of Contract Critical Path Method (CPM) Schedule.
- C. Requirements are in addition to those in General Conditions (GC) 2.7, Additional Instructions and Detail Drawings, GC 2.8, Shop or Setting Drawings, GC 3.3 Reports, Records and Data, 3.4, Cooperation with Utilities, and 6.3, Progress Schedule.

1.2 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Formats: Electronic file in its native form (.XER) and in .PDF format.
- C. Schedule submittals:
 - 1. Baseline CPM Schedule: Submit within 60 days after Notice to Proceed.
 - 2. CPM Schedule Update: Submit monthly.

1.3 GENERAL

- A. Schedules shall represent a practical and logical plan to complete the work within the Contract time.
- B. Schedule and execute submittals, manufacturing, delivery, commissioning, and testing in accordance with the Contract Documents.
- C. The submittal of schedules shall be understood to be the Contractor's representation that the schedule meets the requirements of the Contract Documents and that the work will be executed in the sequence and duration indicated in the schedule.
- D. Failure to include any element of work required for performance of the Contract or failure to properly sequence the work shall not excuse the Contractor from completing Work within the Contract Time.
- E. Schedule submittals are subject to the Engineer's approval. The Owner retains the right to withhold appropriate monies (up to the full value of the progress payment) from progress payments until the Contractor submits a schedule in accordance with these provisions.
- F. Use Microsoft Project, Primavera Project Planner, or approved equal software to prepare required schedules.
- G. Develop schedules using industry standard "best practices" including, but not limited to:
 - 1. No open-ended activities.
 - 2. No use of constraints other than those defined in the Contract Documents without the prior approval of the Engineer.

3. No negative leads or lags.
4. No excess leads or lags without prior justification and approval from the Engineer.
5. Schedule shall demonstrate coordination with Owner and all other interested parties.

1.4 BASELINE CPM SCHEDULE

- A. If in the opinion of the Engineer the schedule is determined to be impractical or not in compliance with the Contract Documents, the Contractor shall revise the schedule and resubmit within 14 Days.
 1. Show clearly on the Contract Schedule the sequence and interdependence of activities.
 2. Include dates for submittals for equipment on the critical path, with sufficient time for minimum of one resubmittal.
 3. Indicate on the schedule diagram a clearly defined critical path.
 4. Include with the schedule submittal a detailed written narrative describing the approach and methods for completion of the work. Include assumptions and specific schedule risks identified in development of the schedule.

1.5 MONTHLY CPM SCHEDULE UPDATE

- A. Submit a Monthly CPM Schedule Update.
- B. The Monthly CPM Schedule Update shall have a data date (stated) as of the last day of the corresponding month (for example; for schedules submitted at the beginning of February 2011 the data date shall be 31 January 2011).
- C. The Monthly CPM Schedule Update shall incorporate all progress to-date.
- D. Provide with the monthly CPM schedule update submittal a written narrative. Include the following:
 1. Changes, additions or deletions that have been made to the schedule since the prior month and a reason for each of the changes.
 2. Assumptions made in developing and updating the schedule.
 3. Major risk items that could potentially have an adverse impact to the schedule and how these risks are being addressed.
- E. If in the opinion of the Engineer the schedule is impractical or not in compliance with the Contract Documents, the Contractor shall revise the schedule and resubmit within 7 Days.

1.6 REQUESTS FOR TIME EXTENSIONS

- A. Submit a written request for extension of Contract Time in accordance with Contract Terms and Conditions. Include the following:
 1. Justification for the extension of time, supporting evidence, and specific references to the current approved schedule at the time the qualifying event occurred.
 2. Analysis of a calendar time-scaled CPM network schedule (FRAGNET) and reports depicting the time impact basis of the request with the affected areas prominently highlighted. Use only the current and accepted schedule at the time the qualifying event occurred when determining time extension request.

- B. If the Owner finds that the Contractor is entitled to an extension of time under the Terms and Conditions of the Contract, the Owner will decide the length of extension based upon analysis of the current schedule and data relevant to the extension.
- C. Extensions of time for performance under the Terms and Conditions of the Contract will be granted only to the extent that equitable time adjustments for the affected activity exceed the total float along the relevant path of the accepted current schedule.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 01 33 00 SUBMITTAL PROCEDURES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section applies to Systems Work, which is found in Specification Sections in Divisions 5, 9, 26, and 34.
- B. General requirements and procedures for preparing and submitting product data, shop drawings, samples, and other submittals for review and approval.
- C. Requirements are in addition to those in General Conditions (GC) 2.7, Additional Instructions and Detail Drawings, and GC 2.8, Shop or Setting Drawings.

1.2 DEFINITIONS

- A. Product Data: Includes illustrations, standard schedules, diagrams, performance charts, instructions, and brochures that illustrate physical appearance, size, and other characteristics of materials and equipment for some portion of the work.
- B. Shop Drawings: Drawings, diagrams, schedules and other data specially prepared for the Work by the Contractor or a Subcontractor, Sub-subcontractor, manufacturer, supplier, or distributor to illustrate some portion of the Work.
- C. Samples: Physical examples of materials, equipment, or workmanship that illustrate functional and aesthetic characteristics of a material or product and establish standard by which the work will be judged.
- D. Day: Calendar day.

1.3 SUBMITTALS

- A. Schedule of Submittals: Within 45 Days after the effective date of Notice to Proceed, submit a completed submittal list.
 - 1. Include for each planned submittal:
 - a. Date on which each submittal will be submitted.
 - b. Contract Specifications reference, by Section and Article.
 - c. Intended submission/resubmission date(s).
 - d. Lead time to delivery/anticipated delivery date(s).
 - 2. Highlight submittals that are on the critical path and add each of these submittals as an activity on the CPM Schedule required by Section 01 32 13, Scheduling of Work.
 - 3. Update and resubmit Schedule of Submittals on a monthly basis.

1.4 CONTRACTOR'S RESPONSIBILITIES

- A. Submit in a timely manner:
 - 1. Submit product data and samples not less than 45 days before scheduled procurement. Contractor shall be responsible for scheduling submittals such that the project schedule is not delayed.
 - 2. Submit shop drawings not less than 30 days before work involving such drawings is to be performed as indicated on the Contractor's CPM Schedule.
 - 3. Contractor shall bear the risk when products, equipment, or materials are procured before approval of submittals or work is started before approval of shop drawings.
- B. Review Submittals Before Transmitting to Engineer:
 - 1. Stamp and sign submittals as reviewed and approved by the Contractor before submission, including subcontractor submittals.
 - 2. Coordinate each submittal with the requirements of the Work, placing particular emphasis upon ensuring that each submittal of one trade is compatible with other submittals of that trade and with the submittals of other trades.
 - 3. Submit complete with all relevant data required for review.
 - 4. Contractor shall be responsible for the correctness of the drawings, for shop fits and field connections, and for the results obtained by the use of such drawings.
- C. Attend meetings as requested by the Engineer to address issues related to the review of submittals.

1.5 THE ENGINEER'S REVIEW

- A. Each submittal listed in the Specifications shall be submitted for review and approval by the Engineer. The Engineer will indicate the submittal disposition as follows:
 - 1. NO EXCEPTIONS TAKEN means submittal appears to conform to requirements of Contract Documents, that manufacture, fabrication, assembly, and installation of submitted product may proceed; and submittal need not be resubmitted.
 - 2. EXCEPTIONS AS NOTED - RESUBMISSION NOT REQUIRED means submittal appears to conform to requirements of Contract Documents upon incorporation of reviewer's corrections, and manufacture, fabrication, assembly, and installation of submitted product may proceed. Submittal need not be resubmitted unless Contractor challenges reviewer's exception.
 - 3. EXCEPTIONS AS NOTED - RESUBMISSION REQUIRED means submittal appears to conform to requirements of Contract Documents upon incorporation of reviewer's corrections, and manufacture, fabrication, assembly, and installation of submitted product may proceed after incorporation of reviewer's corrections and verification by Engineer that reviewer's corrections have been properly incorporated into submittal.
 - a. Resubmission is required.
 - b. Resubmit within 30 days of date of reviewer's transmittal.
 - 4. REJECTED means submittal is deficient to the degree that reviewer cannot correct submittal with a reasonable degree of effort, has not made a thorough review of submittal, and submittal needs revision and is to be corrected and resubmitted.

- B. The Engineer will transmit the disposition of the Contractor's submittal within 30 days after submittals have been received.
- C. Incomplete submittal packages will be returned without review.
- D. Include at least 30 days in the Contractor's CPM schedule for the Engineer and other parties to review submittals, unless otherwise specified.
- E. Allow 30 days for review by the Engineer of all re-submittals.
- F. The Contractor shall not be relieved from liability for form, fit, and function of any item, regardless of the Engineer's approval.

1.6 SUBMITTAL PROCEDURES

- A. Provide each submittal listed in the Submittal Article of each Specification Section.
- B. Identify submittals with the Contract Specification number (34 21 19), followed by the Specification Article number (1.03), paragraph number (B) and subparagraph numbers (2 a), followed by the review cycle number of the submittal (.001).
 - 1. Example: 34 21 19-1.03 B 2 a.001
 - 2. For subsequent resubmittals, the name and number must be identical to that of the original submittal, except that the review cycle number is incremented by 1:
 - a. First submittal: Ends in ".001"
 - b. Second submittal: Ends in ".002"
 - c. Third submittal: Ends in ".003"
- C. Submittal Medium: Provide electronic copy in pdf format with bookmarks to separate sections.
- D. Include the following information in each submittal:
 - 1. Contract title and number.
 - 2. Applicable standards, such as ASTM or IEEE.
 - 3. Identification of deviations from the Contract Drawings and Contract Specifications.
 - 4. Contractor's stamp, initialed or signed, certifying:
 - a. Dimensional compatibility of the product with the space in which it is intended to be used.
 - b. Review of submittals for compliance with the specified requirements.
 - c. Compatibility of the product with other products with which it is to perform or with which it will be contiguous.
 - 5. Professional Engineer's stamp, where required in Specifications.
- E. Attach a transmittal form to each submittal.

1.7 CHANGES

- A. Changes in Reviewed Submittals: Changes in reviewed submittals will not be permitted unless those approved submittals with changes have been resubmitted and reviewed, in the same manner as the original submittal.
- B. Changes in products for which shop drawings, product data, or samples have been submitted will not be permitted unless those changes have been accepted and approved, in writing, by the Engineer. Updated shop drawings, product data, and/or samples shall be provided to the Engineer for review and approval prior to procurement.
- C. Supplemental Submittals: Initiated by the Contractor for consideration of corrective procedures.
 - 1. Shall contain sufficient data for review.
 - 2. Make supplemental submittals in the same manner as initial submittals.

1.8 PRODUCT DATA

- A. Clearly indicate on product selection tables which product and which options are being provided.
- B. Line through or delete information that is not applicable to the Contract.

1.9 SHOP DRAWINGS

- A. Drawings shall be fully legible. Text on 22 x 34 drawings shall not be smaller than 1/8 inch and on 11 x 17 drawings shall not be smaller than 1/16 inch.
- B. Include a title block in the lower right hand corner that identifies the Contractor, Subcontractor, Contract by number and title, subject matter of the drawing, sheet number, date of the original issue of the drawing, and the serial number and date of each revision. Where required by Specification, provide an area in the title block or nearby for Professional Engineer's stamp.
- C. Submittal Stamp and Action Block Space: Include a 5-inch square blank space, in the lower right corner, just above the title block, in which the Engineer may indicate the action taken.
- D. Provide sufficient dimensions on drawings so that size and location may be determined without calculation.
- E. Sample Drawings: The first drawings submitted by Contractor will be reviewed for conformance. Once approval is given, use this approved drawing format as the standard and prepare subsequent drawings to a quality equal to the approved standard.

1.10 SAMPLES

- A. Furnish to the Engineer samples indicated in the Contract Documents or these Specifications. Submit samples without charge, with shipping charges prepaid. Materials for which samples are required shall not be used in the Work until samples are reviewed.
- B. Label each sample with the following data:
 - 1. Name, number, and location of project.
 - 2. Name of Contractor.
 - 3. Material or equipment represented, and location in the project.
 - 4. Name of producer, brand, trade name if applicable, and place of origin.
 - 5. Date of submittal.

- C. Approval of a sample will be only for characteristics and use named in submittal and approval, and shall not be construed to change or modify any Contract requirement.
- D. Test samples as required by Contract Specifications.
- E. Samples of material from local sources shall be taken by or in the presence of the Engineer; otherwise, samples will not be considered for testing.
- F. Failure of any material to pass specified tests will be sufficient cause for refusal to consider, under this Contract, any further samples of the same brand, make, or source of that material. The Engineer reserves the right to disapprove any material that has previously proven unsatisfactory in service.
- G. Samples of material delivered on site or in place may be taken by the Engineer for Quality Assurance testing and will not be returned to the Contractor. Failure of samples to meet Contract requirements will annul previous approvals of item tested.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 01 42 00 REFERENCES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section applies to Systems Work, which is found in Specification Sections in Divisions 5, 9, 26, and 34.
- B. Definitions of Specification terms.
- C. Explanation of Specifications style.
- D. Referenced Standard Drawings and Specifications.
- E. Reference Standards.

1.2 DEFINITION OF SYSTEMS SPECIFICATIONS TERMS

- A. Engineer: The City Engineer or Owner's Designated Representative, as defined in General Provisions 3.1, City Engineer's Authority/Owner's Designated Representative.
- B. Furnish, Install, and Provide:
 - 1. Furnish: To supply and deliver to project site, ready for installation.
 - 2. Install: To place in position for service or use.
 - 3. Provide: To furnish and install, complete and ready for intended use.
- C. Owner: The City of El Paso.

1.3 SPECIFICATION STYLE

- A. These specifications are written in imperative mood and streamlined form. This imperative language is directed to the Contractor, unless specifically noted otherwise. The words "shall be" or "shall comply with", as appropriate, are included by inference where a colon (:) is used within sentences or phrases.
- B. Examples:
 - 1. "Prepare meeting minutes within 3 days following the meeting," means that the Contractor shall prepare the meeting minutes.
 - 2. "Adhesive: Spread with a notched trowel" means "adhesive shall be spread with a notched trowel" and the Contractor is responsible for this work.

1.4 REFERENCE STANDARDS

- A. Reference standards are referenced in other sections of the Specifications to establish requirements for the Work. These references are identified in each section by document number and title.
- B. Applicability of Standards: Unless the Contract Documents include more stringent requirements, applicable industry standards have the same force and effect as if bound or copied directly into the Contract Documents to the extent referenced. Such standards are made a part of the Contract Documents by reference.

- C. Conflicting Requirements: Where compliance with two or more standards is specified and the standards establish different or conflicting requirements for minimum quantities or quality levels, comply with the most stringent requirement. Refer uncertainties and requirements that are different, but apparently equal, to the Engineer for a decision before proceeding.
- D. Publication Dates: Comply with standards in effect as of date of the Contract Documents, unless otherwise indicated.
- E. Copies of Standards: Each entity engaged in Work on this Contract should be familiar with industry standards applicable to its construction activity.
 - 1. Copies of applicable standards are not bound with the Contract Documents.
 - 2. Where copies of standards are needed to perform a required construction activity, obtain copies directly from publication source.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification
SECTION 01 43 00
SYSTEMS QUALITY ASSURANCE

PART 1 - GENERAL

1.1 SUMMARY

- A. Section applies to Systems Work, which is found in Specification Sections in Divisions 5, 9, 26, and 34.
- B. Requirements for Contractor to establish, implement and maintain an effective Quality Program to manage, control, document and assure work complies with requirements specified in the Contract Documents.

1.2 REFERENCE STANDARDS

- A. This Section incorporates by reference the latest revisions of the following documents:
 - 1. Federal Transit Administration (FTA)
 - a. FTA Quality Guidelines.
 - 2. International Organization of Standards
 - a. Quality Management Systems – Fundamentals and Vocabulary - ISO 9000 -2008
 - b. Quality Management Systems – Requirements - ISO 9001 -2008

1.3 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Qualifications:
 - 1. Quality Assurance Manager, within 30 days after Notice to Proceed (NTP).
 - 2. Independent Testing Laboratories, minimum of 30 days before scheduled use.
 - 3. Quality Control Inspectors.
- C. Quality Program Plan, within 60 Days after NTP.
- D. Testing Laboratory Inspection and Test Reports, within 30 days after completion of the inspection or test.
- E. List of Subcontractors and subconsultants within 45 Days after NTP. Provide updates at least 30 days prior to each new subcontractor or subconsultant beginning work on Contract.
- F. Document Control Procedure, within 15 Days after effective date of Notice to Proceed.

1.4 CONTRACTOR QUALITY ASSURANCE REQUIREMENTS

- A. Quality Assurance (QA) Manager: Assign a QA Manager responsible for managing and acting on all quality matters and who has authority to act on all quality matters as a representative of Contractor.
 - 1. Quality Assurance Manager cannot have responsibilities for this Contract that conflict or appear to conflict with his or her responsibility for quality matters.

2. Qualification of Contractor QA Manager:
 - a. Minimum 5 years overall quality experience.
 - b. Minimum 2 years prior experience as a QA Manager, on transit project(s) of comparable complexity to this Contract.
 - c. Minimum 2 years as a Quality Control (QC) Manager or Supervisor, Quality Engineer, Quality Auditor or QC Inspector.
3. QA Manager must be approved by the Engineer. At the sole discretion of the Engineer, Contractor may be required to replace QA Manager.
4. QA Manager's responsibilities include development and implementation of Quality Program Plan.

B. Quality Program Plan (QPP):

1. Develop a plan that addresses the 15 quality elements identified in FTA Quality Guidelines.
2. Provide descriptions of, and references to Quality procedures and work instructions, including specified requirements unique to this Contract, that relate to quality system elements defined in Quality Management Systems – Fundamentals and Vocabulary ISO 9000 and Quality Management Systems – Requirements ISO 9001.
3. Include the following elements in Contractor QPP:
 - a. QA/QC Organization and staff, including job description and an organizational chart showing relationship between Contractor's General Manager, Project Manager, Quality Manager, Subcontractors, and consultants.
 - b. Documented Quality System.
 - c. Design Control.
 - d. Document Control and Submittal Management.
 - e. Subcontractor, Consultant and Supplier Control.
 - f. Identification, Traceability and Receiving, Handling, Storage and Control of Products, Materials and Equipment.
 - g. Process Control and control of special fabrication processes, i.e. welding, plating, and soldering.
 - h. Inspection and Testing.
 - i. Control of measuring and test equipment.
 - j. Inspection and Test Reporting.
 - k. Identification, Control and Correction of Non-conforming Conditions.
 - l. Corrective Actions.
 - m. Quality Records.
 - n. Training.
 - o. Configuration control for software.
 - p. Change control for factory drawings, fabrications, assembly, wiring, testing, and as-built drawings.

C. Independent Testing Laboratories:

1. Employ services of Independent Testing Laboratories if required by Contract Documents, to confirm acceptable quality of materials, parts, and equipment not currently certified by test laboratories.
2. Employ only Independent Testing Laboratories that are currently certified by a nationally or state recognized regulatory agency or an industrial sponsored organization.
3. Obtain approval to use Independent Testing Laboratories from the Engineer before commencing any Work for which testing is required by Contract Documents. Independent Testing Laboratories must have special inspection capability and certification.

D. Quality Control Inspectors:

1. Employ qualified or certified quality control inspectors and test technicians with a minimum of 2 years quality control experience or testing experience for Work they are responsible for inspecting and testing.
2. Upon request from the Engineer, provide qualifications and certifications of the quality control inspectors.
3. Quality control inspectors must report directly to the Contractor's QA Manager and cannot have responsibilities for this Contract that conflict or appear to conflict with his primary responsibility for quality matters.
4. Mobilize the number of experienced quality control inspectors necessary to perform the Quality Control requirements commensurate with the ratio of work crew size to inspectors and the type of work requiring specific types of inspectors.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

3.1 QUALITY PROGRAM PLAN

- A. Submit ISO 9001 certification or submit a Quality Program Plan, as described.
- B. Documented Quality System:
 1. Describe plans, procedures, and organization necessary to design, procure, install, inspect, and test to achieve compliance with the requirements of Contract Documents.
 2. Include operations, both on-site and off-site including fabrication, manufacturing and suppliers.

3.2 SYSTEMIC FAILURES

- A. Monitor component failures during the commissioning, testing, and warranty phase.
- B. Systemic Failure: Failure of 10 percent or more of the same components used for the same function during this time period.
- C. Within 30 days of receiving notification of systemic failure, begin a program to repair or replace all components of the type involved in the systemic failure.
- D. Develop the repair or replacement for the components to remedy the nature and probable cause of the component failure.
- E. The proposed repair or replacement shall be submitted to the Engineer for approval.
- F. Components shall be replaced at no cost to the Owner.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 01 46 00 SYSTEM ASSURANCE

PART 1 - GENERAL

1.1 SUMMARY

- A. Section applies to Systems Work, which is found in Specification Sections in Divisions 5, 9, 26, and 34.
- B. Support for the Owner's Safety Certification Program.

1.2 REFERENCE STANDARDS

- A. This Section incorporates by reference the latest revisions of the following documents:
- B. U.S. Department of Transportation, Federal Transit Administration
 - 1. DOT-FTA-MA-90-5006-02-01, Handbook for Transit Safety and Security Certification
<http://transit-safety.volpe.dot.gov/publications/safety/SafetyCertification/pdf/SSC.pdf>

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

3.1 SAFETY CERTIFICATION PROGRAM

- A. The Owner may comply with FTA guidelines to implement a Safety Certification Program (reference DOT-FTA-MA-90-5006-02-01).
- B. Support the Owner's implementation of the program as directed by Engineer.
- C. Participation includes activities such as assisting the Owner with development of checklists and documentation, identifying submittals that satisfy requirements of the Certifiable Item List, providing standards to which components are designed and tested, and identifying safety-related instructions in training and maintenance documents.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 01 78 23 OPERATION AND MAINTENANCE DATA

PART 1 - GENERAL

1.1 SUMMARY

- A. Section applies to Systems Work found in Specification Sections in Divisions 5, 9, 26, and 34. See Section 34 23 96, OCS Installation and Maintenance Manuals, for additional OCS operation and maintenance data requirements.
- B. Operation and Maintenance (O&M) Manuals for Systems Work, including traction power/electrical.
- C. Renewal Parts Catalogs. See Section 34 23 66, OCS Mandatory Spare Parts and Section 34 23 64, OCS Special Tools for OCS requirements.

1.2 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. O&M Manuals:
 - 1. Submit one for each type of Systems Work:
 - a. Traction power/Electrical: Submit minimum of 90 days before scheduled energization of first substation.
 - b. OCS: Submit Installation and Maintenance Manuals minimum of 90 days before scheduled energization of first substation,
 - 2. For initial review, prepare one complete hard copy set and one electronic version for each manual.
 - 3. After final approval of submitted O&M manual submit 10 hard copy sets and 5 electronic copies of each manual.
- C. Renewal Parts Catalogs for each type of Systems Work: Submit at the same time as O&M manuals.

PART 2 - PRODUCTS

2.1 OPERATION AND MAINTENANCE MANUALS

- A. Format:
 - 1. Include the following in each volume, specific to that volume of the manual:
 - a. Frontispiece: Preceding and facing the title page, showing a recognizable illustration of the equipment described.
 - b. Title Page: Include the name and function of the equipment, manufacturer's identification number(s), and the Contract Specifications number(s) and title(s).
 - c. Table of Contents: List the sections and subsection titles with the page on which each starts and a list of included drawings for each section or subsection.

2. Format of content:

- a. Information shall cover the exact equipment provided and shall not consist of marked up general catalog data.
- b. Delete information on material or equipment not used.
- c. Include drawings and diagrams for major assemblies and subassemblies.
- d. Include descriptive brochures providing physical and functional description of the equipment.
 - 1) Brochures shall be original, printed materials or high quality color prints from electronic media.
 - 2) Brochures shall not be photocopies.

3. Dividers: Insert dividers with identifying tabs to separate sections of the manual.

4. Pages: 8-1/2 inches by 11 inches in size or folded to that size.

5. Binders: Heavy duty, D-ring, locking, three-ring binders not filled to more than 2/3 of their capacity. Binders shall be a maximum of 3" wide.

6. Paper: 47 pound bond.

B. Appendices:

1. Include the following in each systems O&M manual.

2. Glossary

3. Bill of Materials:

- a. Provide complete with all necessary information, including part numbers and catalog item numbers if applicable, for identifying parts.
- b. Identify parts or assemblies obtained from another manufacturer by the name of that manufacturer and its identifying part number.
- c. Supply the size, capacity, or other characteristics of the part if required for identification.

4. Torque table for all types of bolts used in bolted connections.

5. Spare Parts and Special Tools:

- a. Provide a list of contractual and recommended spare parts
- b. Provide a list of special tools required for maintenance.

6. Safety: Safety precautions.

7. Testing: Copies of Field Acceptance Testing procedures and test reports.

8. Warranty information.

9. Others appendices as needed.

C. Traction Power/Electrical:

1. Provide maintenance and operating instructions for all equipment and systems installed, including the following:

2. Installation:
 - a. Pre-installation inspection.
 - b. Installation verification checklist.
 - c. Torque: Include manufacturer's recommended torque information for each type of bolted connection used.
 - d. Calibration.
 - e. Preparation for operation for initial installation.
3. Operation:
 - a. Performance specifications.
 - b. Operating limitations.
 - c. Include step-by-step procedures for
 - 1) Starting: Provide start-up checklist.
 - 2) Restarting.
 - 3) Operating.
 - 4) Shutdown.
 - 5) Emergency requirements.
4. Preventative Maintenance:
 - a. Include step-by-step procedures for
 - 1) Inspection.
 - 2) Operation checks.
 - 3) Cleaning.
 - 4) Lubrication.
 - 5) Adjustments.
5. Corrective Maintenance:
 - a. Include step-by-step procedures for
 - 1) Repair.
 - 2) Disassembly.
 - 3) Reassembly of the equipment for proper operation.
6. Overhaul:
 - a. Parameters that indicate an overhaul is required.
 - b. Disassembly.
 - c. Parts to replace.

- d. Adjustment, cleaning, etc. for parts not replaced.
 - e. Reassembly of the equipment for proper operation.
 - f. Preparation for operation after overhaul.
- D. OCS: Refer to Section 34 23 96, OCS Installation and Maintenance Manuals for requirements.

2.2 RENEWAL PARTS CATALOG

- A. Enumerate and describe every component with its related parts, including supplier's number, Contractor's number, Drawings Apparatus Reference number, and provision for entry of the Owner's part number.
- B. Use cut-away and exploded drawings to aid identification of parts not readily identified by description.
- C. Parts common to different components, such as bolts and nuts, shall bear the same Contractor's number with a reference to other components in which they are found.
- D. For each part or component, list all the assemblies of which it is a component.
- E. Standard parts:
 - 1. Identify commercially available items such as common standard fastenings, fuses, lamps, galvanized pipe, nuts and bolts, etc., by standard hardware nomenclature besides Contractor's number.
 - 2. Furnish a separate list of these items in the catalog with adequate information to order these items through commercial channels.
- F. Furnish a complete itemization of servicing materials (oils, paints, special compounds, greases, etc.) required and component requiring its use.
- G. Furnish ordering and procurement information required for components and subassemblies to the lowest level replaceable component. Ensure that the Owner will not need to request information from Contractor at a future date.
- H. Submit lists in the form of reproducible Bills of Materials suitable for loose-leaf binding adequately cross-referenced to related drawings and Bills of Material.
- I. Refer to Section 34 23 66, OCS Mandatory Spare Parts for OCS spare parts requirements.

PART 3 - EXECUTION

3.1 REVISIONS

- A. If subsequent modifications to the equipment require revised operation and maintenance procedures:
 - 1. Revise the O&M Manuals to show the equipment as installed.
 - 2. Revise by issue of replacement pages to the final O&M Manuals, or by reissue of the O&M Manuals, at the Engineer's option.
 - 3. Submit the revisions to the O&M Manuals not later than 30 Days following revision of the equipment.

3.2 SPECIAL SUBMITTAL PROCEDURES

- A. Work with Engineer to review O&M Manuals together in a meeting environment, if requested
- B. Revise manuals in accordance with directions and comments from both meeting inputs and formal mark-ups (by reviewers)
- C. Resubmit as required in accordance with Section 01 33 00, Submittal Procedures.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification
SECTION 01 78 39
PROJECT RECORD DOCUMENTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section applies to Systems Work found in Specification Sections in Divisions 5, 9, 26, and 34. See Section 34 23 90, OCS Installation Records, for additional OCS project record document requirements.
- B. Requirements for Systems as-built drawings.

1.2 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Incremental Submission of As-Built Drawings
 - 1. Upon request from the Engineer, make available copies of selected as-built drawings in color.
 - 2. Incremental as-built drawings requested by the Engineer shall be stamped "As-Built", signed, and dated by Contractor.
- C. Final Submission of As-Built Drawings:
 - 1. At completion of Work, and before requesting Final Acceptance of Work, deliver Final as-built drawings to the Engineer.
 - 2. Stamp drawings "As-Built Record."
 - 3. Submit five hard copies and three electronic copies on CD or DVD in AutoCAD (latest version) and in PDF formats.
 - 4. Submit as-built drawings and include the following information:
 - a. Date of submission.
 - b. Project title and number.
 - c. Contractor's name and address.
 - d. Certification that as-built drawings as submitted are complete and accurate.
 - e. Signature of Contractor or its authorized representative.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

3.1 MAINTENANCE OF AS-BUILT DRAWINGS

- A. During factory wiring and testing of a TPSS, or other equipment, immediately update drawings or documents affected by a change in the circuits or equipment.
- B. During on-site installation and testing, maintain in each TPSS plan books of approved shop drawings, and immediately update drawings affected by a change in the circuits or equipment.
- C. Protect drawings from damage.
- D. Update as-built documents continuously during the course of construction.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 01 79 00 DEMONSTRATION AND TRAINING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section applies to Systems Work found in Specification Sections in Divisions 5, 9, 26, and 34. See Section 34 23 97, OCS Maintenance Staff Training, for additional OCS demonstration and training requirements.
- A. Requirements for instruction and training of Operations and Maintenance personnel in the management, operation, and maintenance of provided equipment and systems.

1.2 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Submit drafts of the Training Materials and Instructor Guides 3 months before the start of training.
- C. Submit resumes of proposed instructors.
- D. Submit final versions 1 month prior to the start of training. Training shall not commence until the Training Program Plan and Instructor Guides are approved by the Engineer.
- E. Include videos if videos are used in training. Submit on DVD in MPEG-4 format.
- F. Submit Training Reports not later than 1 week after completion of course.

1.3 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Instructors shall be fluent in English and experienced in the system for which they are conducting training.

PART 2 - PRODUCTS

2.1 TRAINING PROGRAM

- A. Design program to train the Owner's maintenance and operations personnel in details of furnished equipment and systems and enable them to operate, service, and maintain systems such that systems will perform and continue to perform in accordance with requirements of this Contract.
- B. Provide a logically related sequence of separate courses covering System Operation, Overall System Maintenance, and Equipment Operation and Maintenance.
- C. Ensure operations and maintenance personnel are fully trained prior to start of passenger service.
- D. Operations and Maintenance Personnel Qualifications:
 - 1. Assume personnel to be trained have only basic skills pertinent to their craft.
 - 2. Assume Operations and Maintenance personnel to be trained have no knowledge of features of specific equipment or systems to be taught.

2.2 TRAINING COURSES

A. Course requirements:

1. Include classroom, hands-on, and/or field instruction, as appropriate, and models, mockups, documentation, and aids to carry out the program.
2. Class Sizes: Unless otherwise specified elsewhere in these Specifications, the Owner will be able to send up to 10 participants to each of the training courses specified.
3. Duration: Maximum 8 hours per day.
4. Training Location and Classrooms: Conduct training courses in facilities provided by the Owner. The facilities will be equipped with tables and chairs.
5. Provide video players and projectors as required.
6. Provide instructors who are fluent in English.
7. Provide literature and equipment necessary to train personnel.
8. Training on actual system equipment and spare equipment will be permitted; however, such use shall not interfere with pre-revenue tests and system demonstrations.

B. Equipment Operations and Maintenance Training:

1. Provide training in the operation and maintenance of equipment systems provided.
2. Provide hardware training including, but not limited to:
 - a. Equipment operation.
 - b. Troubleshooting procedures, including field diagnostics and test equipment.
 - c. Interface with other equipment.
 - d. Preventative maintenance procedures.
3. Provide Operations and Maintenance personnel with a thorough knowledge of the equipment and its operation, its interface with other equipment, and the capabilities and use of test equipment.
4. Provide participants with theoretical background and hands-on experience in troubleshooting, repair procedures, and preventive maintenance procedures.
5. Enable Operations and Maintenance personnel to develop a self sufficient hardware maintenance team for the equipment.
6. Include a page by page review and explanation of approved O&M Manuals.

C. Supplemental Training:

1. Provide extended, duplicate, or additional training for the systems provided, as deemed necessary by the Engineer, due to modification of systems and equipment configuration made after completion of the scheduled training courses.

2.3 TRAINING MATERIALS

- A. Provide Owner-specific materials prepared specifically for use as training aids.
- B. Use reference manuals, operating and maintenance manuals, and user's manuals as supplementary training materials.

- C. Tailor principal documents used for training to reflect the Owner's equipment and specific user requirements.
- D. Provide each course participant copies of training manuals and other pertinent material prior to commencement of courses.
- E. The Owner will retain the master and two additional copies of training manuals and materials as reference documentation.
- F. Upon completion of each course, instructor's manuals, training manuals, and training aids become the property of the Owner unless such items are specifically exempted by the Engineer.
- G. The Owner reserves the right to copy training materials and aids for use in Owner-conducted training courses.
- H. Provide special tools, equipment, training aids, and other materials required to train course participants. Provide sufficient quantity of special tools and other training equipment for the number of participants attending the course.
- I. Use actual hardware and photographs taken during the manufacturing process wherever possible. Actual hardware used for training must pass re-inspection and acceptance testing prior to being placed in service.
- J. Videos:
 - 1. Use prerecorded lectures as supplementary training material.
 - 2. Do not use videos as a replacement for a classroom instructor, or as the primary training vehicle.
 - 3. The Owner shall have the right to videotape training courses presented by the Contractor. The Owner shall also have the right to use these videotapes to train personnel in the future.

2.4 INSTRUCTOR GUIDES

- A. Detail instructor actions during program presentation, one Instructor Guide for each training session.
- B. Supply the following materials with each Instructor Guide:
 - 1. Microsoft PowerPoint presentation file on disk.
 - 2. Slides, pictures, charts used in support of the lesson.
 - 3. One complete student handout package.
 - 4. One copy of material referenced in the lesson.
- C. Each Instructor Guide shall be arranged in sections:
 - 1. Section 1, Title: short and descriptive, must contain lesson name and target audience.
 - 2. Section 2, Time to Teach: Designate estimated time to teach for each Instructor Guide, an approximate period that may vary due to student number and knowledge level.
 - 3. Section 3, Objective: One or more performance-based objectives each of which specifies:
 - a. End-of-course performance expected of the student.
 - b. Conditions under which behavior will occur.
 - c. Measurable minimum level of performance considered acceptable.

4. Section 4, References: List sources of material presented, include maintenance manuals, test equipment manuals, and other documents developed for this Contract.
5. Section 5, Materials List: List materials needed to teach content, include training aids (such as overhead transparencies, charts, projectors, and size and type of facility), student handouts (such as books, drawings, and schematics), equipment (such as tools parts for disassembly).
6. Section 6, Introduction: Cover at least the following areas:
 - a. Introduction of subject covered by the lesson.
 - b. Lesson objectives.
 - c. An outline of the lesson.
 - d. A schedule of the lesson's activities.
7. Section 7, Presentation: Presentation should be in outline form, narrative is acceptable but not necessary.
 - a. Suggested numbering system:

```

A.
B.
    1.
    2.
        a.
        b.
            (1)
            (2)
                (a)
                (b)

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- D. Presentation portion of the Instructor Guide should be detailed enough to:
 1. Serve as a written record of the specific facts and information.
 2. Allow another instructor with knowledge of the area to teach the class.
 3. Ensure that the subject delivery is consistent each time the lesson is given.
 4. Allow replication of all evaluations, tests, and quizzes given in conjunction with this lesson.

PART 3 - EXECUTION

3.1 TRAINING REPORTS

- A. Grading system: Establish to report progress of each trainee during a course and identify requirements for further training for each participant.
- B. Training Reports:
 1. Include graded tests (without names) with raw scores.
 2. Include a summary of the results of monitoring and evaluating.
 3. Include records of student attendance and performance.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification
SECTION 05 05 00
COMMON WORK RESULTS FOR METALS

PART 1 - GENERAL

1.1 SUMMARY

- A. Galvanizing
- B. Shop applied coatings for metal fabrications
- C. Welding

1.2 DEFINITIONS

- A. Galvanneal: Hot-dip zinc coating process followed by heating steel to approximately 1000 to 1050 degrees F and holding at this temperature to allow the zinc coating to alloy with iron by diffusion between the molten zinc and iron from the steel.
- B. Hot-dip galvanizing: Dipping steel members and assemblies into molten zinc for lasting, or long-term corrosion protection. Resultant zinc coating fuses permanently with base steel material.

1.3 REFERENCE STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents, or the version required by the Authority Having Jurisdiction:
- B. The American Society for Nondestructive Testing (ASNT)
 - 1. Recommended Practice No. SNT-TC-1A: Personnel Qualification and Certification in Nondestructive Testing
- C. American Welding Society (AWS)
 - 1. AWS A5 Series, Filler Metal Specifications
 - 2. AWS B1.10M/B1.10, Guide for the Nondestructive Examination of Welds
 - 3. AWS D1.1/D1.1M, Structural Welding Code – Steel
 - 4. AWS D1.3/D1.3M, Structural Welding Code – Sheet Steel
 - 5. AWS QC1, Standard for AWS Certification of Welding Inspectors
- D. ASTM International (ASTM):
 - 1. ASTM A53/A53M, Pipe, Steel, Black and Hot-Dipped Zinc-Coated, Welded and Seamless
 - 2. ASTM A123/A123M, Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
 - 3. ASTM A143/143M, Safeguarding against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement
 - 4. ASTM A153/A153M, Zinc Coating (Hot-Dip) on Iron and Steel Hardware
 - 5. ASTM A384/A384M, Safeguarding against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies
 - 6. ASTM A385/A385M, Providing High-Quality Zinc Coatings (Hot Dip)

7. ASTM A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
8. ASTM A780/A780M, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
9. ASTM B6, Standard Specification for Zinc
10. ASTM B117, Standard Practice for Operating Salt Spray (Fog) Apparatus
11. ASTM D522, Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings
12. ASTM D968, Standard Test Methods for Abrasion Resistance of Organic Coatings by Falling Abrasive
13. ASTM D1308, Standard Test Method for Effect of Household Chemicals on Clear and Pigmented Organic Finishes
14. ASTM D2247, Standard Practice for Testing Water Resistance of Coatings in 100% Relative Humidity
15. ASTM D2248, Standard Practice for Detergent Resistance of Organic Finishes
16. ASTM D2485,
17. ASTM D2794, Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)
18. ASTM D3170, Standard Test Method for Chipping Resistance of Coatings
19. ASTM D3359, Standard Test Methods for Measuring Adhesion by Tape Test
20. ASTM D3363, Standard Test Method for Film Hardness by Pencil Test
21. ASTM D3451, Standard Guide for Testing Coating Powders and Powder Coatings
22. ASTM D4060, Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser
23. ASTM D4541, Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers
24. ASTM D4585, Standard Practice for Testing Water Resistance of Coatings Using Controlled Condensation
25. ASTM D4798, Standard Practice for Accelerated Weathering Test Conditions and Procedures for Bituminous Materials (Xenon-Arc Method)
26. ASTM D5894, ASTM D6132, Standard Test Method for Nondestructive Measurement of Dry Film Thickness of Applied Organic Coatings Using an Ultrasonic Gage
27. ASTM D6695, Standard Practice for Xenon-Arc Exposures of Paint and Related Coatings
28. ASTM D7091, Standard Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals
29. ASTM E94, Guide for Radiographic Testing
30. ASTM E164, Practice for Ultrasonic Contact Examination of Weldments
31. ASTM E165, Standard Test Method for Liquid Penetrant Examination

32. ASTM E709, Guide for Magnetic Particle Examination
 33. ASTM E1032, Method for Radiographic Examination of Weldments
 34. ASTM G151, Standard Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources
 35. ASTM G155, Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials
- E. The Society for Protective Coatings (SSPC)
1. SSPC-PA 1, Shop, Field, and Maintenance Painting of Steel
 2. SSPC-PA 2, Procedure for Determining Conformance to Dry Coating Thickness Requirements
 3. SSPC-PS 13.01, Epoxy Polyamide Painting System
 4. SSPC-SP6, Commercial Blast Cleaning
 5. SSPC-SP8, Pickling

1.4 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Certification:
1. Furnish notarized certificates of compliance with ASTM and AWS requirements specified in this Section.
 2. Certifications shall state that the galvanizing or finish is in conformance with this Section.
 - a. Each certificate for galvanizing shall be signed by the galvanizer and include a detailed description of all material and methods used.
 - b. Each certificate for shop applied coatings shall be signed by the applier and include a detailed description of all material and methods used.
- C. Shop Applied Coatings:
1. Qualifications Submittals (for each applicator) minimum 60 days before work is scheduled.
 - a. Evidence that the applicator is an approved and authorized applicator of the coating formulator's products.
 - b. Certification that the applicator has been authorized to provide the coating formulator's warranty.
 - c. Applicator's quality control procedures.
 2. Literature and Instructions:
 - a. Descriptive and technical data sheets describing products proposed for use. Include, for each indicated substrate, chemical and performance characteristics of each coating system.
 - b. Documentation of application process.

3. Color Samples:
 - a. Match colors specified on 12-inch long sections of extrusions and 12-inch square heavy gage sheet metal, materials matching indicated substrates, for the Engineer's review.
 - b. Include additional samples for each indicated color demonstrating color match of recommended field touchup materials.
4. Testing:
 - a. Certified test results evidencing compliance of applied coatings with the application and testing requirements specified in this Section.
5. Repair:
 - a. Manufacturer recommended repair procedures and materials.
 - b. If repair is necessary, submit repair sample after salt spray testing.
6. Maintenance Information and Field Touchup Materials:
 - a. Manufacturer's recommended touchup and maintenance materials and procedures for field touchup of marred or damaged coatings using air-drying spray materials in matching colors.

D. Welding:

1. Welder Qualifications:
 - a. Submit certified copies of qualification test records for each welder, welding operator and tack welder to be employed in the Work 150 Days after NTP.
 - b. Comply with requirements of AWS D1.1/D1.1M, and AWS QC1.
 - c. Submit welders' identification marks (I.D.) for each welder along with qualifications.
2. Welding Procedures:
 - a. Before welding, submit the procedure that will be used for qualifying welding procedures.
 - b. For procedures other than those prequalified in accordance with AWS D1.1/D1.1M, submit a copy of procedure qualification test records in accordance with the qualification requirements of AWS D1.1/D1.1M.
3. Welding Records and Data:
 - a. Retain radiographs upon completion of fabrication.
 - b. Retain certifications that magnetic particle and dye-penetrant inspections have been satisfactorily completed.
 - c. Submit records of ultrasonic testing to the Engineer upon completion.
 - d. If field welding is permitted, submit descriptive data for field welding equipment.
4. Mill Certificates:
 - a. Retain mill certificates and certified copy of reports for analyses and tests required by referenced ASTM and AWS specifications.

1.5 QUALITY ASSURANCE

A. Coating Applicator Qualifications:

1. Engage an experienced coating applicator that is licensed or approved by the powder coating manufacturer.
2. Applicator shall have demonstrated the ability to properly apply the coating and have quality control procedures firmly established in its shop.
3. Engineer may, at his option, visit the applicator's facility to confirm adherence to quality control procedures.

B. Single Source for Galvanized and Finished Metal Fabrications:

1. Use products of one manufacturer on each specific item to ensure exact color match and finish appearance.

C. Welding:

1. Welder Qualifications:

- a. Welders, Welding operators and tack welders shall be qualified in accordance with AWS D1.1/D1.1M.
- b. For sheet steel, welders shall be qualified in accordance with AWS D1.3/D1.3M, Qualification Section.
- c. Welding shall be done by qualified, certified welders who make only those welds for which they have been qualified in accordance with AWS, or other approved qualifying procedures.
- d. Records of welder qualification tests shall be made available for review upon the Engineer's request.

2. Welding Procedure Qualification:

- a. Welding procedures shall be prequalified or qualified in accordance with AWS D1.1/D1.1M.
- b. For sheet steel, proposed welding procedures shall be qualified in accordance with AWS D1.3/D1.3M. Prequalification is not applicable to sheet steel.

3. Welding Inspector Qualifications: Welds to be inspected by the Contractor shall be inspected and certified by an AWS Certified Welding Inspector (CWI), certified in accordance with AWS QC1.

4. Testing Personnel Qualification:

- a. Personnel performing nondestructive testing shall be qualified and certified in accordance with the American Society for Nondestructive Testing Recommended Practice No. SNT-TC-1A.
- b. Only persons certified for NDT Level I and working under a NDT Level II person or persons certified for NDT Level II may perform nondestructive testing.

5. Weldability of Steel: For structural steel requiring impact test qualification and for corrosion resistant structural steel, establish weldability of steel and procedures for welding it by qualification in accordance with AWS D1.1/D1.1M, to match the notch toughness and weathering characteristics of the base metal.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, handle, and store metal fabrications in a manner that prevents damage to the item, its galvanizing, and its finish.

1.7 WARRANTY

- A. Furnish written warranty starting on date of conditional acceptance stating that shop applied coating will not blister, peel, crack, chalk, change color or have other forms of degradation during warranty period.
- B. Coating failure:
 - 1. In the event that coating failure occurs within warranty period, replace item indicating coating failure, including full cost of labor and materials for such replacement.
 - 2. Replacement items shall be new and finished with same type coating meeting requirements of this section.
 - 3. Replacement items shall match adjacent members.
- C. The Engineer may permit field repairs in lieu of replacement, provided coating failure is minor in scope and field repair material and method employed match its adjacent member. Repairs shall be compatible with original surface.

PART 2 - PRODUCTS

2.1 GALVANIZING

- A. Hot-Dip Galvanized Coating:
 - 1. Wherever materials are called out as “hot-dip galvanized” or “galvanized,” provide a zinc coating after fabrication using the hot-dip galvanizing process complying with ASTM A123/A123M and A153/A153M.
 - a. Galvanizing bath shall contain 0.05 to 0.09 percent nickel by weight.
 - b. The coating is intended to be hot-dip galvanizing applied in addition to normal manufacturer’s finish.
 - c. Specified materials or products that are not readily available in the specified hot-dip finish, shall be “custom” hot dipped after manufacture by an independent galvanizer.
 - 2. Where finishes are called out as galvanized and the specified product cannot be hot-dip galvanized either before or after manufacture, provide the specified product with a finish that will perform equal to hot-dip galvanized as approved by the Engineer.
 - 3. Before galvanizing: Inspect iron and steel hardware before galvanizing and verify suitability for galvanizing. Replace items that are not suitable for galvanizing.
 - 4. Material Suitable for Galvanizing:
 - a. Geometrically suitable for galvanizing as specified in ASTM A384/A384M and ASTM A385/A385M.
 - b. Steel materials suitable for galvanizing include structural shapes, pipe, sheet, fabrications, and assemblies.
 - c. Material chemically suitable for galvanizing. Verify with supplier or fabricator.
 - 5. Zinc for galvanizing: Conform to ASTM B6, as specified in ASTM A123/A123M.

6. Preparation of Steel Members:
 - a. Galvanized members requiring shop fabrication shall be welded, drilled, and assembled, as applicable, before galvanizing.
 - b. Galvanized members that are to be field welded or that are to be shop welded to ungalvanized members shall be masked to a distance of 1 inch from weld line before galvanizing.
 - c. Members to be galvanized shall be abrasively cleaned, in accordance with SSPC-SP6.
 - d. Pickle steel surfaces before hot-dip galvanizing in accordance with SSPC-SP8.
 7. Steel members, fabrications, and assemblies to be galvanized after fabrication:
 - a. Method: Hot-dip process in accordance with ASTM A123/A123M.
 - b. Weight of zinc coating: Conform to requirements of ASTM A153/A153M.
 - c. Components: Smooth after galvanizing.
 8. Embrittlement: Safeguard against steel embrittlement in accordance with ASTM A143/A143M.
 9. Warpage:
 - a. Safeguard against warpage or distortion of steel members in accordance with ASTM A384/A384M.
 - b. Notify the Engineer of potential warpage problems that require modification in design before proceeding with steel fabrications. Costs for alternative designs shall be performed at no additional cost to the Owner.
 10. Finish, uniformity, and adherence of coating: ASTM A153/A153M.
- B. Galvannealed Coating:
1. Wherever materials are called out as "galvannealed," provide a zinc-iron alloy coating applied by a hot-dip process complying with ASTM A653/A653M.
- C. Mechanical Galvanizing shall not be used.

2.2 SHOP APPLIED POWDER COAT

- A. Provide shop-applied polyester triglycidyl isocyanurate (T.G.I.C.) coatings, thermo-cured color finish systems based on dry, powdered resins, commonly known as "powder coat."
1. Primer: Apply primer compatible with powder top coat, as confirmed by powder coat manufacturer.
 2. Top Coat:
 - a. Acceptable Manufacturer/Product: Tiger Drylac, or approved equal.
 3. Anti-Graffiti Coating:
 - a. Apply as final coat on exterior surfaces.
 - b. Powder coating intended for easy removal of typical spray paint used for graffiti.
 - c. Acceptable Manufacturer/Product: Tiger Drylac Series 44, or approved equal.

- B. Dry Film Thickness:
1. Primer: 3.5 mils minimum.
 2. Top coat: 3.5 mils minimum.
 3. Anti-graffiti coating: As recommended by manufacturer.
- C. Coating shall meet the testing requirements of ASTM D3451 and other standards indicated below:
1. Physical Properties of Powder Coatings:
 - a. Measurement of film thickness: ASTM D6132 or D7091.
 - b. Abrasion resistance: ASTM D968.
 - c. Adhesion: ASTM D3359, Method B, 5B.
 - d. Elongation (flexibility): Mandrell Bending Test, ASTM D522, equal to or greater than 3 mm.
 - e. Household chemical resistance: ASTM D1308.
 - f. Detergent resistance: ASTM D2248.
 - g. Chip resistance: ASTM D3170.
 - h. Gloss:
 - 1) Interior: 25 to 40 percent reflective gloss.
 - 2) Exterior: ASTM D523, 80 to 90 plus.
 - i. Pencil hardness:
 - 1) Interior: ASTM D3363, F minimum.
 - 2) Exterior: ASTM D3363, 4H (minimum).
 - j. Impact resistance: ASTM D2794, 80 (in/lb), no appearance of cracks.
 2. Accelerated Artificial Weathering: ASTM D6695, ASTM G151, ASTM G155.
 3. Accelerated Environmental Exposure:
 - a. Salt spray:
 - 1) Interior: ASTM B117, maximum undercut failure of 1/16 inch at scribed test lines; no blistering.
 - 2) Exterior: ASTM B117, 500 hours, maximum undercut failure 1 (mm); no blistering.
 - b. Humidity Resistance: ASTM D2247, 500 hours, maximum undercutting 1 mm, no blistering.
- D. Perform mechanical processing such as sawing, drilling, milling, cutting, and bending before applying shop applied coatings.

E. Cleaning:

1. Clean surfaces to be coated as follows:
 - a. Remove all dust, dirt, and other surface debris by vacuuming, wiping dry with clean cloths or compressed air.
 - b. Rinse scrubbed surfaces with clean water until foreign matter is flushed from surface.
 - c. Allow surfaces to drain completely and allow to thoroughly dry.
 - d. Use water blasting only when necessary for extreme cases of contamination by oily residue and where hand washing is impractical.
 - e. If the above procedures do not clean the substrate surfaces, clean the surfaces with high pressure water washing.

F. Pretreatment:

1. Wash parts in a four stage iron-phosphate washer for steel or zinc-phosphate washer for galvanized steel, or in accordance with primer manufacturer's recommendations.
2. Dry parts before application of power coating.
3. Treatment of the substrate: ASTM D3451.

G. Application:

1. Edges: Treat and finish as required to ensure specified minimum dry film coating thickness is achieved. Precoating of edges may be required.
2. Apply primer in accordance with manufacturer's written application instructions.
3. Apply top coat in accordance with manufacturer's written application instructions.
4. Allow surfaces to cure for time period in accordance with manufacturer's cure curves.
5. Inspect parts after cooling.

H. Color:

1. TPSS Enclosure Exterior: Color will be provided by the Engineer.
2. TPSS Enclosure Interior: RAL 9010, Pure White.
3. Electrical Equipment: Munsell Color System 8.3G 6.1/0.5 (ANSI 61 grey).

2.3 SHOP-APPLIED PAINT COATING SYSTEM

A. General Requirements:

1. Coatings must be certified VOC compliant and conform to applicable regulations and EPA standards.
2. Material Compatibility:
 - a. Provide primers, finish coat materials and related materials that are compatible with one another and the steel substrate.
 - b. Furnish documentation from manufacturer demonstrating compatibility in both application and service based on testing and field experience.

3. Material Quality:

- a. Provide highest grade of coatings as regularly manufactured by acceptable coating manufacturers.
- b. Materials not displaying manufacturer's identification as a best-grade product will not be acceptable.

B. Primer:

1. Polyamide epoxy, 4-6 mils DFT.
2. Primer must meet or exceed the following performance criteria:
 - a. Abrasion Resistance per ASTM D4060 (CS17 Wheel, 1,000 grams load), 1 kg Load: 200 mg loss.
 - b. Adhesion per ASTM D4541: 1050 psi.
 - c. Corrosion Weathering per ASTM D5894, 13 Cycles, 4,368 Hours: Rating 10 per ASTM D714 for blistering; Rating 7 per ASTM D610 for rusting.
 - d. Direct Impact Resistance per ASTM D2794: 160 inch pounds.
 - e. Flexibility per ASTM D522, 180 degree Bend, 1 inch Mandrel: Passes.
 - f. Pencil Hardness per ASTM D3363: 3B.
 - g. Moisture Condensation Resistance per ASTM D4585, 100 degrees F, 2000 Hours: Passes, no cracking or delamination.
 - h. Dry Heat Resistance per ASTM D2485: 250 degrees F.

C. Top Coat:

1. High solids, pigmented, aliphatic polyurethane, minimum 4 mils DFT.
2. Color: As directed by Engineer.
3. Topcoat must meet or exceed the following performance criteria:
 - a. Abrasion Resistance per ASTM D4060, CS17 Wheel, 1,000 Cycles 1kg Load: 87.1 mg loss.
 - b. Adhesion per ASTM D4541: 1050 psi.
 - c. Direct Impact Resistance per ASTM D2794: Greater than 28 inch pounds.
 - d. Indirect Impact Resistance per ASTM D2794: 12-14 inch pounds.
 - e. Dry Heat Resistance per ASTM D2485: 200 degrees F.
 - f. Salt Fog Resistance per ASTM B117 9,000 Hours: Rating 10 per ASTM D714 for blistering.
 - g. Flexibility per ASTM D522, 180 Degree Bend, 1/8 Inch Mandrel: Passes.
 - h. Pencil Hardness per ASTM D3363: 2H.
 - i. Moisture Condensation Resistance per ASTM D4585, 100 degrees F, 1000 Hours: No blistering or delamination.
 - j. Xenon Arc Test per ASTM D4798: Pass 300 hours.

D. Acceptable Manufacturers/Brands:

1. AkzoNobel/ICI Paints/Devoe High Performance Coatings;
2. Carboline;
3. PPG Protective and Marine Coatings ;
4. Tnemec; or approved equal.

E. Shop-Applied Paint Coating Application:

1. Prepare steel in accordance with paint manufacturer's recommendations.
 - a. Verify with paint manufacturer that proposed surface cleaner is compatible with approved paint coating system.
 - b. Apply paint as soon as possible after surface preparation.
2. Primer:
 - a. Shop-apply in accordance with SSPC-PA 1, SSPC-PA 2, SSPC-PS 13.01, and manufacturer's instructions.
 - b. Verify DFT in accordance with SSPC-PA 2.
3. Top coat:
 - a. Shop-apply in accordance with manufacturer's instructions.

2.4 WELDING

A. Rod/Electrodes:

1. Electrodes for structural plate, shapes, pipe, tubes, and bars shall conform to AWS A5 Series Standards and shall be coated rods or wire of size and classification number as recommended by their manufacturers for the conditions of actual use.
2. Electrodes for sheet steel shall conform to AWS A5 Series Standards and shall be coated rods or wire of size and classification number, as recommended by their manufacturers for the conditions of actual use.
3. Matching filler metal requirements shall conform to AWS D1.1/D1.1M, Table 3.1.

B. Stud Shear Connectors: Only products of manufacturers qualified in accordance with AWS D1.1/D1.1M will be accepted for this Work.

C. Shop Welding:

1. Perform shop welding as indicated in accordance with AWS D1.1/D1.1M, and AWS D1.3/D1.3M, as applicable to the Work.
2. Welders shall mark adjacent to completed welds their welder I.D., using metal stamp, metal engraving, keel, paint stick, or other appropriate marking material.
3. Welding of stud shear connectors shall conform to AWS D1.1/D1.1M, Section 7. "Stud Welding," and the stud manufacturer's instructions.

2.5 SOURCE QUALITY CONTROL

- A. Galvanizer Coordination Drawings: To safeguard against distortion, provide shop drawings to galvanizer of non-standard fabrications, tubular fabrications, fabrications with dimension greater than galvanizer's kettle size, and fabrications with materials of different thicknesses.
- B. Galvanizer's Stamp: Galvanized materials shall be marked with the galvanizer's stamp.
- C. Galvanizing Inspection and Repair:
 - 1. Inspect galvanizing for full coverage and adhesion to steel.
 - a. Grind rough areas to produce a uniform surface.
 - b. Repair field cutting of metal, welds, steel grinding, scratches and other damages, and coat masked areas, in accordance with ASTM A780/A780M, Repair of Hot-Dip Galvanizing.
 - c. Sprayed Zinc: Clean and preheat to assure freedom from loose material, moisture, oil grease, or other foreign matter before applying zinc. Apply zinc coating by metallizing spray to clean and dry surfaces.
 - d. Zinc-Based Solders and Wire:
 - 1) Clean to remove loose material and contaminates, and heat to approximately 572 degrees F.
 - 2) Apply zinc-alloy repair compound by spreading material over heated surface in accordance with compound manufacturer's instructions.
 - 3) Remove repair compound residues with damp cloth or by rinsing with water.
 - e. Organic cold galvanizing coating:
 - 1) Minimum 95 percent metallic zinc by weight in dried film.
 - 2) Approved Manufacturer: ZRC Products Company, or approved equal.
 - 2. Dry film thickness of applied repair materials: Not less than galvanized coating thickness required by ASTM A53/A53M, A123/A123M, or A153/A153M.
- D. Welding Inspections and Tests by the Contractor:
 - 1. Visual Inspection:
 - a. All welds shall be visually examined in accordance with AWS D1.1/D1.1M.
 - b. Quality of welds and standards of acceptance shall be in accordance with AWS D1.1/D1.1M.
 - 2. Inspection and Testing Type Requirements:
 - a. Nondestructive Testing: Conform to AWS B1.10M/B1.10.
 - b. Liquid Penetrant Inspection: Liquid dye penetrant inspection of welds shall conform to ASTM E165.
 - c. Magnetic Particle Inspection: Magnetic particle inspection of welds shall conform to ASTM E709.

- d. Ultrasonic Testing: Comply with AWS D1.1/D1.1M and ASTM E164, as applicable.
 - e. Radiographic Testing: Comply with AWS D1.1/D1.1M and ASTM E94 and ASTM E1032, as applicable.
- 3. Inspect complete and partial joint penetration groove welds and fillet welds using magnetic particle inspection as follows:
 - a. One out of five (20 percent) of complete joint penetration groove welds of tee and corner joints.
 - b. One out of ten (ten percent) of partial joint penetration groove welds and fillet welds.
- 4. Random Testing: Randomly test 10 percent of welds by either liquid penetrant inspection or magnetic particle inspection.
- 5. Additional Testing: If random testing reveals possible flaws, test the welds in question, and additional welds if directed by the Engineer, using ultrasonic or radiographic testing. Requirement for this additional testing shall be at no additional cost to the Owner and shall be at the sole discretion of the Engineer.
- 6. Test complete joint penetration groove welds by radiographic testing as follows:
 - a. One out of ten (ten percent) with thickness equal to or less than 3/4 inch.
 - b. One out of two (50 percent) with thickness greater than 3/4 inch and equal to or less than 1.5 inches.
 - c. 100 percent for thickness greater than 1.5 inches.
 - d. Complete joint penetration groove welds not accessible for radiographic testing shall be subjected to ultrasonic testing. The extent shall be the same as specified for radiographic testing.
- 7. Inspection and Test Results:
 - a. Forward test result information to the Engineer immediately after test results are available, stating the acceptance or rejection of fabricated components, so that repairs and re-inspection or testing may be performed as soon as possible.
- 8. Repairs:
 - a. Repair unacceptable welds in accordance with AWS D1.1/D1.1M.
 - b. Re-inspect or retest repaired or corrected welds as specified for the original weld.
- E. Shop Inspections and Tests by the Engineer:
 - 1. Galvanizing, shop applied coatings, and welds are subject to inspections and tests by the Engineer.
 - 2. The Engineer will make test results available to the Contractor.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Field Welding: Shall be performed as specified for shop welding.

3.2 SITE QUALITY CONTROL

- A. Galvanizing: After delivery of substation, inspect and repair damage to galvanizing.
 - 1. Repair field cutting of metal, welds, steel grinding, scratches and other damages, and coat masked areas, in accordance with ASTM A780/A780M.
 - 2. Dry film thickness of applied repair materials: Not less than galvanized coating thickness required by ASTM A53/A53M, A123/A123M, or A153/A153M.
- B. Shop Applied Coating: After delivery of substation, inspect and repair damage to shop applied coating.
 - 1. Repair minor film scratches and other blemishes in film surfaces in accordance with coating manufacturer's recommended procedures and materials.
 - a. Submit recommended procedures and materials.
 - b. Prepare a sample demonstrating the proposed repair procedures and materials, and subject to salt spray test per ASTM B117.
 - c. Submit the sample after testing.
 - 2. Finished repairs shall match original finish for color and gloss, shall adhere to original finish, and shall exhibit no removal of coating film or blistering during dry adhesion testing when tested in accordance with ASTM D3359.
 - 3. Remove coated items damaged beyond repair and replace with newly fabricated and coated items.
- C. Welding Inspections and Tests:
 - 1. Perform tests of field welds as specified for shop welds.
 - 2. Engineer will perform visual inspections of field welds as specified for shop welds.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 09 67 25 DIELECTRIC EPOXY FLOORING

PART 1 - GENERAL

1.1 SUMMARY

- A. Trowel-applied dielectric, epoxy-resin flooring for traction power substation floors.

1.2 RELATED SECTIONS

- A. Section 34 21 90 – Traction Electrification System Testing

1.3 REFERENCE STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents:
- B. ASTM International (ASTM)
 - 1. ASTM D149, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
 - 2. ASTM D695, Standard Test Method for Compressive Properties of Rigid Plastics
 - 3. ASTM D4541, Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers
 - 4. ASTM F2170, Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using in situ Probes

1.4 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Product Data: Include preparation and installation instructions.
- C. Installer Certificates: Signed by manufacturers certifying that installers comply with requirements.
- D. Operation and Maintenance Data:
 - 1. Submit manufacturer's cleaning and maintenance instructions.
 - 2. Submit immediately after approval of product data.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications:
 - 1. Engage an installer who is certified in writing by epoxy flooring manufacturer as qualified to install manufacturer's products.
 - 2. Workers performing installation must be skilled and experienced in the installation of the approved product.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to assembly site in supplier's original wrappings and containers, labeled with sources or manufacturer's name, material or product brand name, and lot number.
- B. Store materials in their original, undamaged packages and containers, inside a well-ventilated area protected from weather, moisture, soiling, extreme temperatures, and humidity.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Provide flooring capable of the following when applied at 1/4-inch thickness:
 - 1. Dielectric service, in accordance with ASTM D149: 58,000 Vdc.
 - 2. Bond strength to concrete in accordance with ASTM D4541: 400 psi minimum.
 - 3. Abrasion Resistance: Not more than 0.5 grams loss when tested with Tabor abrader with 1000 gram load for 1000 cycles.
 - 4. Compressive strength per ASTM D695: 8500 psi.
- B. Performance of In-Place Flooring: Capable of withstanding testing conditions specified in 34 21 90, Traction Power Substation Testing without arcing or passing current beyond specified limit.

2.2 EPOXY-RESIN FLOORING

- A. Epoxy-Resin Flooring: Subject to compliance with requirements, provide Hallemite Dielectric Grey Amazite by RBC Industries, Inc., or approved equal.
 - 1. Thickness: 1/4 inch nominal.
 - 2. Color: Manufacturer's standard grey.
- B. Materials:
 - 1. Epoxy-Resin Matrix: Manufacturer's standard recommended for use indicated.
 - 2. Aggregates: Silica sand in gradation recommended by resin manufacturer.

2.3 SHOP APPLICATION

- A. Application Conditions:
 - 1. Environmental Limitations: Comply with manufacturer's written instructions for substrate temperature, ambient temperature, moisture, ventilation, and other conditions affecting flooring installation.
 - 2. Provide permanent lighting or, if permanent lighting is not in place, simulate permanent lighting conditions during flooring installation.
 - 3. Close spaces to traffic during flooring application and for not less than 24 hours after application unless manufacturer recommends a longer period.
- B. Preparation:
 - 1. Clean substrates of substances, including oil, grease, and curing compounds, that might impair flooring bond. Provide clean, dry, and neutral substrate for flooring application.
 - 2. Rough sand metallic floors as recommended by manufacturer to insure adhesion.

3. Apply masking at stop points and at adjacent surfaces that are not to be coated, so that the flooring will finish at clean lines.
- C. Epoxy-Resin Flooring Installation:
1. Apply the epoxy to the area shown on Contract Drawings.
 2. Place and finish flooring according to manufacturer's written instructions.
 3. Installation Tolerance: Limit variation in flooring surface from level to 1/4 inch in 10 feet; non-cumulative.
 4. Where the edge joins the bare floor, taper the material from the full thickness to the height of the floor over a minimum of a 2-inch wide area.
 5. Ensure that matrix components and fluids from grinding operations do not stain flooring by reacting with divider and control-joint strips.
 6. Primer: Apply to flooring substrates according to manufacturer's written instructions.
 7. Install epoxy floor coating to a minimum thickness of 1/4 inch as a one piece surface.
 8. Where the epoxy floor covering meets a wall insulating panel, the floor covering shall completely fill gap to a minimum thickness of 1/4 inch.

2.4 PROTECTION

- A. During equipment installation, provide protective covering to keep the epoxy floor clean and free from damage.

2.5 SOURCE QUALITY CONTROL

- A. Inspect floor for cracks and joints. Repair in accordance with manufacturer's recommendations.
- B. Cut out and replace flooring areas that evidence lack of bond with substrate.
- C. Cut out flooring areas in panels defined by strips and replace to match adjacent flooring, or repair panels according to manufacturer's written recommendations, as approved by the Engineer.
- D. Testing: Test in accordance with Section 34 21 90, Traction Electrification System Testing. If flooring fails to provide specified level of electrical insulation, apply additional layers of epoxy until specified levels are achieved.

PART 3 - EXECUTION

3.1 FIELD APPLICATION

- A. Building and premises shall be clean, warm, and dry before installation of dielectric epoxy floor.
- B. Prepare concrete floor as directed by manufacturer to insure adhesion.
- C. Verify that concrete or metal substrates are dry and moisture-vapor emissions are within acceptable levels according to manufacturer's written instructions.
 1. Moisture Testing: Perform tests indicated below.
 - a. In-Situ Probe Test: Perform relative-humidity test using in-situ probes in accordance with ASTM F 2170.
 - b. Proceed with installation only after substrates have a maximum 75 percent relative-humidity-level measurement.

- D. Block drains to prevent the entrance of epoxy-resin.
- E. Requirements of Article titled "Shop Application" apply to field fabrication.

3.2 FIELD QUALITY CONTROL

- A. Inspection: After delivery to site, inspect floor for shipping damage.
- B. Testing: After delivery to site, test in accordance with Section 34 21 90, TPSS Testing, to ensure that floor has not been damaged during shipping.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 22 45 19 SELF CONTAINED EYEWASH EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Self-contained eyewash equipment for installation in substations.

1.2 REFERENCE STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents, or the version required by the Authority Having Jurisdiction:
 - 1. ANSI Z358.1, Standard for Emergency Eyewash and Shower Equipment
- B. American National Standards Institute (ANSI)
 - 1. ANSI Z358.1, Standard for Emergency Eyewash and Shower Equipment

1.3 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Product Data:
 - 1. Eyewash station.
 - 2. Eyewash solution cartridge.
- C. Operation and Maintenance Data:
 - 1. Submit manufacturer's operating and maintenance instructions on products specified in this Section.
 - 2. Submit immediately after approval of product data

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Eyewash Stations:
 - 1. Self-contained eyewash station meeting the requirements of ANSI Z358.1 using factory-sealed cartridges of eyewash solution.
 - 2. Eyewash stations shall be suitable for wall mounting at locations indicated on Contract Documents and incorporate a fluid reservoir for discharged solution.
- B. Eyewash Saline Assembly:
 - 1. Factory-sealed cartridge assembly containing contaminant-free, pH-balanced saline solution with integral nozzle(s) for solution delivery in a gentle flow meeting ANSI Z358.1 requirements.
 - 2. Cartridge assemblies shall have a two-year shelf life from date of manufacture.

2.2 MANUFACTURER

- A. Provide eyewash station and cartridges that are products of a single manufacturer.
- B. Acceptable Manufacturer/Product: Honeywell Safety Products, Fendall Pure Flow 1000 or approved equal.

2.3 FACTORY ASSEMBLY

- A. Provide one eyewash station complete with eyewash fluid in each substation.
- B. Install eyewash station in accordance with manufacturer instructions immediately adjacent to battery installation. Locations shall meet requirements of ANSI Z358.1.
- C. Install eyewash solution cartridge(s) in accordance with manufacturer instructions.
- D. Provide translucent 6-mil polyethylene sheeting as a secure and dust-proof, temporary cover over each completed eyewash station.

PART 3 - EXECUTION

3.1 FIELD INSTALLATION

- A. Requirements of Article titled "Factory Assembly" apply to field installation.
- B. Provide factory-sealed eyewash saline assembly upon delivery of TPSS to site. Assembly shall have minimum 22-months shelf life remaining at time of delivery.

3.2 SITE QUALITY CONTROL

- A. Remove temporary cover after final commissioning of substation and verify that eyewash station is clean and ready to use.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification
SECTION 26 05 00
COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

- A. General electrical requirements for materials, assembly, and installation.
- B. Labeling and listing of electrical equipment and products, and field evaluation for products not listed.
- C. Software to upload and download settings for intelligent electronic devices (IEDs).
- D. Electrical components, including the following:
 - 1. Wiring devices.
 - 2. Cover plates.
 - 3. Individual control relays.
- E. Field applied coatings.
- F. Seismic design.
- G. Identification, including the following:
 - 1. Nameplates.
 - 2. Conduit identification labels.
- H. Requirements of this section apply to all 26 xx xx sections and 34 21 xx sections.

1.2 RELATED SECTIONS

- A. Section 05 05 00 – Common Work Results for Metals
- B. Section 26 05 33 – Raceway and Boxes
- C. Section 34 21 05 – Common Work Results for Traction Electrification System (TES)

1.3 DEFINITIONS

- A. Intelligent Electronic Device (IED): See definition in Section 34 21 05, Common Work Results for Traction Electrification System (TES).
- B. Authority Having Jurisdiction (AHJ): As defined in NFPA 70, Article 100, Definitions.

1.4 REFERENCE STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents, or if standard is adopted by the City of El Paso, the latest revision adopted:
 - 1. ASTM D570, Standard Test Method for Water Absorption of Plastics
- B. ASTM International (ASTM)

- C. Institute of Electrical and Electronics Engineers (IEEE)
 - 1. IEEE C2, National Electrical Safety Code
- D. International Conference of Building Officials
 - 1. International Building Code (IBC) (with amendments by the Authority Having Jurisdiction)
- E. National Electrical Contractors Association
 - 1. NECA 1, Standard for Good Workmanship in Electrical Construction
- F. National Electrical Manufacturers Association (NEMA)
 - 1. NEMA WD 1, General Requirements for Wiring Devices
 - 2. NEMA WD 5, Specific-Purpose Wiring Devices
 - 3. NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum)
- G. National Fire Protection Association (NFPA)
 - 1. NFPA 70, National Electrical Code (with amendments by the Authority Having Jurisdiction)
 - 2. NFPA 130, Fixed Guideway Transit and Passenger Rail Systems
- H. Underwriters Laboratories (UL)
 - 1. UL 224, Extruded Insulating Tubing

1.5 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Product Data:
 - 1. Submit manufacturer's product data for products specified in this section.
 - 2. Submit evidence of conformance to referenced standards.
- C. List of Materials: Include materials and equipment proposed for use specified in this section.
 - 1. Give name of manufacturer, brand name, and catalog number of each item.
 - 2. Submit the list complete at one time, with items arranged and identified in numerical sequence by Article and Paragraph numbers.
- D. Identification Schedule:
 - 1. Submit a schedule of proposed nameplates and labels, including material, size, color, text, and location, before ordering.
- E. Submit a request for permission to perform a Field Evaluation for equipment that is not labeled or listed.

F. Shop Drawings:

1. Submit shop drawings showing equipment layouts and fabricated work being provided under these Specifications.
2. Submit shop drawings before fabrication, and within ample time to prevent delays in the Work.
3. Include electrical diagrams for equipment and equipment installation.

G. Seismic Calculations: Submit sealed seismic design and bracing calculations that include equipment and raceways in each Section of these Specifications.

1.6 QUALITY ASSURANCE

A. Compliance with Applicable Standards:

1. Where equipment or materials are specified to conform to the standards of organizations such as ANSI, ASTM, IEEE, and NEMA, submit evidence of conformance for review and record purposes.
2. The label or listing will be acceptable as sufficient evidence that the materials and equipment do conform to the specified standards.
3. Submit evidence of compliance to seismic safety requirements of the International Building Code and NFPA 70 and local amendments to these codes.

B. Qualifications:

1. Workers shall be experienced in the type of work they are performing.
2. Ensure workers performing Work under Division 26 meet the qualification and licensing requirements of the State.

C. Listed and Labeled Equipment and Material:

1. Provide wherever standards for these products have been established.
2. Materials that are not listed or labeled require approval by Engineer before use.
3. Products that have not been tested or certified for the use intended shall not be used when equivalent listed or labeled materials are available.
4. Electrical equipment and material not listed or labeled shall be provided with a Field Evaluation label provided by an approved Testing Laboratory, and certifying that the equipment conforms to the requirements of UL, ANSI, and other standards as required by the Authority Having Jurisdiction.
 - a. This product evaluation may be performed in the factory or on-site as approved by Engineer.
 - b. Submit to Engineer a request for permission to perform a Field Evaluation, whether in the factory or onsite.

D. Perform Work in compliance with the following industry standards and regulations:

1. NFPA 70, National Electrical Code (with amendments of the Authority Having Jurisdiction).
2. NFPA 130, Standard for Fixed Guideway Transit and Passenger Rail Systems.
3. NECA 1, Standard for Good Workmanship in Electrical Construction.

4. IEEE C2, National Electrical Safety Code.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Provide materials and equipment of design, sizes, and ratings as indicated and suitable for the intended purpose.
- B. Methods of fabrication, assembly, and installation shall comply with specified standards.
- C. Provide only new products that are free from defects.

2.2 SOFTWARE

- A. Provide interface and configuration software for uploading settings to and downloading event history from intelligent electronic device (IED).
- B. Provide software that will work with each type of IED provided under a Division 26 specification section.
- C. Software shall work on a standard laptop with Microsoft Windows 7 operating system.

2.3 ELECTRICAL COMPONENTS

- A. Wiring Devices:

1. Switches:

- a. Provide 120 - 277 Vac tumbler-type toggle switches conforming to minimum requirements of NEMA WD 1, heavy-duty general-use type.
- b. Provide switches that operate in any position and are fully enclosed with entire body and cover of molded phenolic, urea, or melamine. Do not use fiber, paper, or similar flammable insulating material for body or cover.
- c. Mounting yoke:
 - 1) Metal with plaster ears, insulated from the mechanism and fastened to the switch body by bolts, screws, rivets, or other substantial means.
 - 2) Dimensions: Section of the yoke normally intended to bear on the surface outside the box shall have a minimum over-all dimension of 3/4 inch, measured at right angles to the longitudinal axis of the yoke.
- d. Switch contacts: Silver or silver alloy.
- e. Wiring: Back or side wired.
- f. Terminals: Screw type or combination screw-clamp type.
- g. Terminal screws: No. 8 or larger, captive or terminal type.
- h. Switch Color: Grey, or as selected by Engineer.
- i. Applications:
 - 1) Incandescent or Fluorescent Lighting: Fully-rated 20 A at 120 V or 277 V.
 - 2) Straight resistance loads: May be snap switches as specified in this section, of the proper rating up to 30 A at 120 - 277 V.

- j. Testing: Capable of withstanding tests as outlined in NEMA WD 1. If requested by Engineer, submit evidence that the types of switches proposed have satisfactorily withstood these tests.

2. Receptacles:

- a. Receptacle Standards: NEMA WD 1, heavy-duty general-use type.
- b. Convenience Receptacles:
 - 1) Bodies and Bases: Fire-resistant, nonabsorptive, hot-molded phenolic.
 - 2) Plaster ears: Metal, integral with supporting member.
 - 3) Receptacle Color: Grey, or as selected by Engineer.
 - 4) Configuration: 20R, single- or duplex-type as indicated.
 - 5) Wiring: Back or side wired.
 - 6) Terminals: Screw type or combination screw-clamp type.
 - 7) Contacts: Double-grip bronze type with spring steel backup clips so that both sides of each male prong of the plug will be in firm contact. Applies also to grounding contact.
- c. Locking-blade Receptacles: NEMA WD 5.
- d. GFCI Receptacles: Duplex receptacles, 120 V, 60 Hz, 20 A with built-in test, reset buttons, and ground fault tripped indication.
 - 1) Trip: Interrupt the circuit within 1/30 second on a 5 milliampere earth leakage current.
 - 2) Use GFCIs designed for end of run installation or with provisions for feeding through to protect other outlets on the circuit.

B. Cover Plates:

- 1. Interior cover:
 - a. Device covers: Raised, galvanized steel.
 - b. Provide multi-gang plates where required. Segmented cover plates are not acceptable.
- 2. Exterior and wet or damp location cover:
 - a. Die-cast aluminum.
 - b. Listed for wet locations, rated NEMA 3R, with neoprene gasket.
 - c. Padlockable.
 - d. NEC-compliant "while-in-use" cover.
 - e. Depth: Minimum 3-1/4 inches.
 - f. Acceptable Manufacturer/Product:
 - 1) Intermatic WP1010MC;
 - 2) Thomas & Betts, Model CKMUV; or approved equal.

C. Individual Control Relays:

1. Provide convertible contacts rated a minimum of 10 A, 600 V unless otherwise indicated.
2. Verify coil voltage, and number and type of contacts.
3. Drop-out Voltage: 80 V.
4. Provide NEMA 250 Type 1 enclosures.

2.4 FIELD APPLIED COATINGS

- A. Galvanized Steel Field Coating: Organic cold galvanizing coating as specified in Section 05 05 00, Common Work Results for Metals.
- B. Oxide inhibiting joint compounds:
1. Non-petroleum based compound with evenly suspended zinc particles.
 - a. Approved Manufacturer/Product: Burndy, Penetrox A-13, or approved equal.

2.5 SEISMIC DESIGN

- A. Equipment provided under this Contract shall meet seismic requirements specified in the International Building Code (IBC) with modifications by the Authority Having Jurisdiction.
- B. Submit calculations and design for suitable anchorage and bracing performed and sealed by a structural engineer registered in the State of Texas.

2.6 IDENTIFICATION

- A. Nameplates:
1. Engraved three-layer melamine laminated plastic, not less than 3/32-inch thick. Provide nameplates with black letters on a white background unless otherwise noted.
 2. Equipment nameplates: 1-5/8 inches high with 7/8-inch high characters minimum.
 3. Device nameplates: 7/8-inch high and have 1/4-inch high characters.
 4. Other equipment nameplates shall be sized and lettered according to the equipment and application as approved by the Engineer.
- B. Conduit Identification Labels: Laminated, machine-printed labels with high-strength adhesive, black letters on yellow background.
1. 2-inch and smaller conduits: 3/4-inch wide
 2. 2-1/2-inch and larger conduits: 1-inch wide labels.
 3. Approved Manufacturer/Product: Brother TZ-series tape, or approved equal.
 4. Use label printer compatible with chosen tape.
- C. Identification Schedule: Submit a proposed schedule of nameplates and labels.

2.7 UTILITY METERING

- A. See Section 34 21 05, Common Work Results for Traction Electrification System (TES).

2.8 FACTORY ASSEMBLY

A. General Requirements:

1. Provide products in accordance with product listings, manufacturer's recommendations, relevant codes and regulations, and standard industry practice for electrical installations.
2. Provide electrical materials, equipment, appurtenances, and accessories in locations as indicated and in accordance with NECA 1.
3. Provide supporting members, fastenings, framing, hangers, bracing, brackets, straps, bolts, and angles as required to set and connect the Work rigidly.
4. Control erection tolerance requirements so as to not impair the strength, safety, serviceability, or appearance of the installations.
5. Complete installation: Contract Drawings show electrical equipment diagrammatically and do not show all accessories or fittings that may be required. Provide complete and operable electrical systems and installations in conformance with these Specifications.

B. Anchoring and Support:

1. Do not weld electrical materials for attachment or support.
2. Provide anchor bolts and anchorage items as required, and field check to ensure proper alignment and location.
3. Provide templates and layout drawings to ensure correct placing of anchorage items in concrete.

C. Wiring:

1. Provide wiring systems complete as indicated and required for proper service.
2. Provide ample slack wire for motor loops, service connections, and extensions.

D. Wiring Devices and Cover Plates:

1. Install switches, receptacles, special purpose outlets, and cover plates complete in accordance with NECA 1, NFPA 70, and local electrical codes.
2. Locate wiring devices at heights in accordance with NECA 1, except as otherwise indicated.
3. Provide GFCI duplex receptacles on the interior and exterior of prefabricated substation enclosures and where indicated.
4. Provide a cover plate for each switch, receptacle, and special purpose outlet.
5. Exterior and damp locations:
 - a. Provide cast metal outlet boxes with threaded hubs as specified in Section 26 05 33, Raceway and Boxes.
 - b. Provide with weatherproof cover plate, as specified above.

E. Installation in Vicinity of Rectifier and Dc Distribution Equipment:

1. Within 6 feet of dc rectifier, dc switchgear, and dc distribution equipment, provide non-metallic raceways, boxes, covers, equipment, and supports.
2. Alternatively, provide substantial insulating barriers to prevent simultaneous contact with dc equipment enclosures and adjacent metal surfaces.

F. Torquing:

1. Torque bolted connections in accordance with manufacturer's recommendations.
2. Use a torque wrench calibrated within the past 12 months and bearing a calibration sticker.
3. Torque busses and bus connections per manufacturer's recommendations or according to the following table.

Silicon Bronze Bolt Standard Dry Torque		
Bolt Size Inches	Threads/ inch	Inch Pounds
1/4	20	68.8
	28	87
5/16	18	123
	24	131
3/8	16	219
	24	240
7/16	14	349
	20	371
1/2	13	480
	20	502
9/16	12	632
	18	697
5/8	11	1030
	18	1154
3/4	10	1416
	16	1382

4. Torque cable connections per manufacturer's recommendations, or according to the following table.

Steel Bolt Standard Dry Torque in Foot Pounds							
		SAE Grade					
Bolt Size Inches	Course thread/ inch	0-1-2	3	5	6	7	8
1/4	20	6	9	10	12.5	13	14
5/16	18	12	17	19	24	25	29
3/8	16	20	30	33	43	44	47
7/16	14	32	47	54	69	71	78
1/2	13	47	69	78	106	110	119
9/16	12	69	103	114	150	154	169
5/8	11	96	145	154	209	215	230
3/4	10	155	234	257	350	360	380

5. Apply torque mark after torquing connection.

G. Equipment Identification:

1. Provide a nameplate with a unique number for each piece of equipment such as switchboard sections, panelboards, circuit breakers, and devices.
2. Where multiple devices are enclosed in one cubicle, section, or enclosure, provide a nameplate for each individual device, located on the interior or exterior of the cubicle, section, or enclosure, as approved by Engineer.

3. Where locations of nameplates cannot be adequately described in the identification schedule specified above in the Part 2 Article titled "Identification", provide shop drawings showing the location of each label.
4. Obtain approval for material, size, color, text, and location of nameplates and labels before installing.
5. Fasten nameplates to the equipment or device enclosure door with stainless steel machine screws.

PART 3 - EXECUTION

3.1 FIELD INSTALLATION

- A. Requirements of Article titled "Factory Assembly" apply to field installation.
- B. Seal equipment enclosures against dust, whenever dusty conditions are present inside the rooms or outside, during the construction period.
- C. Provide seismic anchorage and bracing in accordance with submitted design and calculations.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 26 05 10 COMMON WORK RESULTS FOR SYSTEMS CONDUCTORS AND CABLE

PART 1 - GENERAL

1.1 SUMMARY

- A. Products used with systems conductors and cable.
- B. Wire and cable type requirements.
- C. Requirements for circuit separation.
- D. Requirements for installation of systems conductors and cable for electrical power and traction power.
- E. This section does not apply to the installation of OCS conductors.

1.2 RELATED SECTIONS

- A. Section 26 05 00 – Common Work Results for Electrical
- B. Section 26 05 29 – Hangers and Supports for Electrical Systems
- C. Section 34 21 90 – Traction Electrification System Testing

1.3 DEFINITIONS

- A. Low-voltage cable: A single or multiconductor insulated cable rated 2000 V or less.

1.4 REFERENCE STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents, or if standard is adopted by the City of El Paso, the latest revision adopted:
 - 1. IEEE 1210, Standard Tests for Determining Compatibility of Cable-Pulling Lubricants With Wire and Cable
- B. Institute of Electrical and Electronics Engineers (IEEE)
 - 1. IEEE 1210, Standard Tests for Determining Compatibility of Cable-Pulling Lubricants With Wire and Cable
- C. National Electrical Contractors Association (NECA)
 - 1. NECA 1, Standard Practice of Good Workmanship in Electrical Contracting
- D. National Fire Protection Association (NFPA)
 - 1. NFPA 70, National Electrical Code (with City of El Paso amendments)
- E. Underwriters Laboratories (UL)
 - 1. UL 224, Extruded Insulating Tubing

1.5 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Submit Product Data on the following items:
 - 1. Cable pulling equipment, including tension measuring device with calibration certificate.

2. Cable racks.

C. Cable Pulling Calculations:

1. Submit cable pulling calculations for approval no later than 30 working days before scheduled installation. Include the following information:
 - a. Circuit identification
 - b. Manufacturer and type of cable
 - c. Cable dimensions
 - d. Unit weight of cable
 - e. Maximum permissible pulling tension
 - f. Maximum permissible side-wall pressure
 - g. Pulling lubricant used and assumed friction coefficient.
 - h. Estimated length of pull
 - i. Recommended direction of pull
 - j. Total degrees of conduit bend
 - k. Inside radius and position in run of conduit bends
 - l. Conduit size
 - m. Calculated jam ratio
 - n. Calculated peak pulling tension
 - o. Calculated peak side-wall pressure

D. Cable Pulling Report:

1. Submit final report for each cable installation within 30 working days of installation and include the following information:
 - a. Information originally provided with Cable Pulling Calculations (see above)
 - b. Date of installation and name of Engineer's witness
 - c. Actual length of pull
 - d. Actual direction of pull
 - e. Actual maximum pulling tension
 - f. Calculated maximum sidewall pressure at worst-case conduit ell and pulling sheave.

E. As-built Drawings:

1. Submit as specified in Section 01 78 39, Project Record Documents.
2. Show splices in cable on as-built drawings.

1.6 NOTIFICATION

- A. Notify Engineer 48 hours before cable pulling operations where cable pulling calculations were required.
- B. Adjust schedule as necessary to permit observation.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Ship each unit securely wrapped, packaged, and labeled for safe handling in shipment and to avoid damage.
- B. Deliver wires and cables to the site in unbroken standard coils or reels with attached tag bearing manufacturer's name, wire trade name, and listing information.
- C. Store wire and cable in secure and dry storage facility, in accordance with NECA 1.

PART 2 - PRODUCTS

2.1 CONDUIT MANDREL AND BRUSH

- A. Mandrel: Flexible non-metallic segmented type.
 - 1. Size no smaller than 1/4 inch less than the size of conduit.
 - a. Approved Manufacturer: Greenlee, or approved equal.
- B. Brush: Wire brush type, sized for conduit.

2.2 CABLE PULLING LUBRICANT

- A. Commercially-available non-petroleum-based product that will not damage cable sheathing or insulation or cause corrosion to metal boxes or fittings of the raceway system.
 - 1. Product shall be approved by the cable manufacturer.
 - 2. Product shall meet the requirements of IEEE 1210.
- B. Provide special-formulation pulling lubricant where required due to low ambient temperature or where a lower coefficient of friction is required to meet pulling tension and sidewall pressure limits.
- C. Acceptable Manufacturer/Product:
 - 1. Polywater J, or Polywater WJ for low ambient temperature, or approved equal.

2.3 CABLE RACKS

- A. UL listed, heavy duty, glass-reinforced nylon, suitable for the support of low voltage insulated cables without additional insulators, with sufficient load capacity to support the installed and future cables.
- B. Size: Racks shall be of adequate length to support the number of cables indicated without stacking, with space for 25 percent additional cables.

2.4 CABLE PROTECTORS

- A. Nylon, flanged, split tube to insert in duct end to protect cable from damage.
- B. Approved Manufacturers/Products:
 - 1. Greenlee 488-2 or 488-3;

2. Condux 08042301 or 08042300; or approved equal.

2.5 INSULATED CABLE CLAMPS

- A. Thermoplastic elastomer, high-dielectric split-sleeve cable bushing and two-piece, galvanized or stainless-steel clamp assembly for installation on hot-dip galvanized framing channel.
- B. See Section 26 05 29, Hangers and Supports for Electrical Systems, for framing channel requirements.
- C. Approved Manufacturer/Product:
 1. B-Line, Insulclamp, or approved equal.

2.6 CABLE SUPPORTS

- A. Designed to support cable in vertical conduit and provide a watertight seal.
- B. Malleable or ductile iron with hot-dip galvanized finish, threaded for rigid conduit.
- C. Approved Manufacturer/Product: OZ Gedney Cable Support, Type C Compound, or approved equal.

2.7 CABLE TIES (TIE WRAPS)

- A. Self-extinguishing nylon with a temperature range of minus 40 degrees F to 185 degrees F.
- B. Cable ties shall have a locking hub or head with a stainless steel locking barb on one end and a taper on the other end.
- C. Width:
 1. Dc feeder cables: Minimum 1/2 inch.
 2. Other applications: Adequate to prevent damage to wire or cable insulation.
- D. Strength: Minimum 250 pounds for dc feeder cables.
- E. Outdoor use: Ultraviolet-resistant material.

2.8 SPLICE AND TERMINAL CONNECTORS

- A. Fittings shall be tool-applied, compression, compatible with conductors on which they are used, and listed for use with provided cable.
- B. No. 10 AWG and smaller conductors:
 1. Wire terminations: Heavy duty, ring type, nylon insulated.
 2. Splices: Self-insulating or provided with an insulating cap or heat-shrink insulating sleeve.
- C. No. 8 AWG to No. 4 AWG: Provide double-bolted NEMA two-hole terminals where rotation of a single-bolted terminal would result in contact or unacceptable clearance with other conductors or the enclosure.
- D. No. 2 AWG to No. 3/0 AWG: Provide terminals with two NEMA-standard bolt holes in tongue unless otherwise indicated.
- E. No. 4/0 AWG and larger conductors: Provide long-barrel, double-compression type, with two NEMA standard bolt holes in tongue unless otherwise indicated.
- F. Compression Tools:

1. Shall apply a hexagonal compression using mechanical, electrical, or hydraulic power mechanism that ensures a complete compression cycle.
2. Shall permanently imprint die information on the completed connection.

2.9 INSULATING MATERIAL FOR SPLICES AND TERMINATIONS

- A. Provide insulating material for terminations of type accepted by Engineer for the particular use, location, and voltage. Mark each tape package to indicate shelf-life expiration date.
- B. Electrical insulating tape for general use: Vinyl plastic with rubber based pressure sensitive adhesive, pliable from temperatures of minus 18 degrees C to 105 degrees C. Verify tape has the following minimum properties when tested in accordance with ASTM D3005:
 1. Thickness: 7 mils.
 2. Breaking Strength: 15 pounds per inch.
 3. Elongation: 200 percent.
 4. Dielectric Strength: 10 kV/mil.
 5. Insulation Resistance (Direct method of electrolytic corrosion): 10 megohms.
- C. Rubber electrical insulating tape for protective overwrapping: Silicone rubber with a silicone pressure-sensitive adhesive. Verify tape has the following minimum properties when tested in accordance with ASTM D1000:
 1. Elongation: 525 percent.
 2. Dielectric Strength: 13 kV.
 3. Insulation Resistance (Indirect Method of Electrolytic Corrosion): 10 megohms.
- D. Heat shrink tubing: Product meeting the electrical and environmental requirements of the application.

2.10 FIREPROOFING TAPE

- A. Fire and arc proof tape, self-extinguishing, and compatible with conductor insulation and jacket.
- B. Tape shall not deteriorate when subjected to water, salt water, gases or sewage.
- C. Approved Manufacturer/Product: 3M, Type 77, or approved equal.

2.11 IDENTIFICATION

- A. Wire Sleeves: Non-fading, heat-shrink plastic, machine-printed sleeve labels.
 1. Approved Manufacturer/Product: Brady Heatex™ labels.
 2. Material: Polyolefin heat shrinkable tubing.
 3. Standards: UL 224.
- B. Cable Tags: Non-fading, plastic, slide in, printed cable tags with holes for attachment to cable with plastic cable ties.
 1. Numbers shall be 1.5 inches long.
 2. Approved Manufacturer/Product: Almetek Industries, Inc., E-Z Tags, or approved equal.

PART 3 - EXECUTION

3.1 WIRE AND CABLE TYPE REQUIREMENTS

- A. Substation power circuits, ac and dc: 600 V single conductor cable.
- B. Within switchgear, where not exposed to medium voltage: 600 V switchboard wire.
- C. Within ac switchgear: 600 V switchboard wire.
- D. Within dc switchgear and rectifier: 2 kV switchboard wire.
- E. Dc feeders: 2 kV single-conductor dc feeder cable.
- F. Conductors installed in the same raceway or vault as 2 kV feeder cables (e.g. blue light conductors): 2 kV switchboard wire.
- G. Cable sizes up to 4/0 AWG in cable tray: Multi-conductor cable.
- H. Surge arresters: Extra-flexible cable.
- I. Use bare conductor for ground wire only.

3.2 CIRCUIT SEPARATION

- A. Physically separate conductors and cables on circuits of different voltages or systems to reduce the possibility of unsafe conditions, interference, or equipment damage.
- B. The following major circuit groups shall not be harnessed or bundled together, shall not run in the same conduit and shall be physically separated and secured in vaults, enclosures, and cable trays.
 - 1. Low-voltage ac circuits.
 - 2. Low-voltage dc circuits: 600 V rated.
 - 3. Low-voltage dc circuits: 2 kV rated.
 - 4. Dc control circuits.
 - 5. Dc traction power positive feeders.
 - 6. Dc traction power negative feeders.
- C. Where these circuit groups share vaults, enclosures, or cable trays, physically separate and secure such that there is a minimum separation of 6 inches.
- D. Where dc traction power positive and negative feeders share the same vault, rack them on opposite sides of the vault.

3.3 MANDRELLING RACEWAYS

- A. Mandrel and brush raceways, including those provided by others, before installing cable.

3.4 CONDUCTOR MARKING

- A. Phase Marking: Conform to the following color coding for ac power cables:

<u>Conductor</u>	<u>480Y/277 V</u>	<u>208Y/120 V</u>
Phase A	Brown	Black
Phase B	Orange	Red
Phase C	Yellow	Blue
Neutral	White	White
Ground	Green	Green

- B. Use solid color insulation or solid color coating for branch circuit phase conductors No. 10 AWG and smaller and neutral and equipment ground conductors.
- C. Use a background color other than white or green for phase conductors with colored tracers.

3.5 CABLE INSTALLED IN RACEWAY

- A. General Requirements:

1. Notify the Engineer 48 hours before installing cables.
2. Inspect wire and cable for damage before installation. Damaged cable shall not be installed.
3. Cable shall not exceed fill limits of NFPA 70.
4. Install all cables to be placed in one duct simultaneously.
5. Install conductors and cables in accordance with NECA 1 and as recommended by the manufacturer.
6. Use extreme care in installing cables so as to avoid twisting, kinking, or injuring cable or its sheath.
7. Apply generous amounts of approved cable pulling lubricant.
8. Use an approved wire cable grip extending not less than 18 inches back from the end of the cable.
9. Do not bend cables during installation, either permanently or temporarily, to radii less than 12 times the outer diameters, except where conditions make the specified radius impractical and shorter radii are permitted by the manufacturer.
10. Immediately seal ends of cable until cable is terminated and protected in manholes.

- B. Cable Pulling Calculations:

1. Perform and submit cable pulling calculations before installing cable in raceways. Refer to Submittals Article, above, for documentation requirements.
2. Perform calculations using industry-accepted pulling software such as PolyWater's 'Pull-Planner.'
3. Calculate Jam Ratio, maximum pulling tension, and maximum side-wall pressure to ensure cable installation will meet manufacturer's requirements.
4. If cable pulling calculations indicate that manufacturer-recommended installation tension or sidewall pressure may be exceeded, recalculate after making one or more of the following changes, as needed, until calculated tension and sidewall pressure are acceptable:
 - a. Modify pulling method.

- b. Reverse pulling direction.
 - c. Provide special pulling lubricant.
 - d. Modify raceway components.
 - e. Add vaults or pull-boxes so that installation will be acceptable.
5. If Jam Ratio indicates a tendency for cables to jam, provide factory- or field-installed cable-wrap or binding before installation or provide factory-multiplexed cables so that jamming will not occur.
6. Revisions to raceway system, cables, or pulling method shall be made at no cost to Owner.

C. Pulling Tension:

- 1. Do not exceed manufacturer's recommended pulling tension and sidewall pressure for cable installed.
- 2. Tensiometer: Provide a calibrated tensiometer that indicates pulling force in pounds at the pulling end under the following circumstances:
 - a. Conduit runs with over 180 degrees of bend, whether pulled by hand or with a cable puller.
 - b. All cable installations where a cable puller is used, whether powered or unpowered.
- 3. During cable installation, record the highest cable tension.
- 4. Using measured cable tension, calculate the highest resulting sidewall pressure, both within conduit run and at pulling sheaves.
- 5. Exceeding manufacturer's recommendations for either parameter will require replacement of cables at no cost to the Owner.

D. Installation with power winches:

- 1. Power winches shall not be used for pulling conductors smaller than 2 AWG in raceways.
- 2. Provide suitable installation equipment to prevent cutting and abrasion of conduits and wire.
- 3. If used, sheaves and pulleys must limit cable sidewall pressure and bend radius to acceptable values.
- 4. Use lubricant and installation procedures as recommended by the cable manufacturer and suitable for expected ambient temperatures.
- 5. Where conductors are pulled using more than three persons at the pulling end, meet requirements for installation with power winches.

E. Installation in Manholes and Pullboxes:

- 1. Pump water out of manholes, hand holes, and pull chambers before installing cable and maintain manholes, hand holes, and pull chambers in a dry condition while cables are being pulled.
- 2. Brush or swab dry and mandrel each conduit before installing cable.
- 3. Install cables in the lowest available duct.

4. Route cables along the manhole or handhole walls providing the longest possible slack or in accordance with approved installation drawings. Form cables closely parallel to the walls.
 5. Prevent cable interference with duct entrances.
 6. Provide cable racks spaced at a maximum of 4 feet and secure cable to racks using cable ties.
 7. Existing manholes and handholes: Where new ducts are to be terminated or where new cables are to be installed, modify the existing locations of cables, cable supports, and grounding as required to provide a properly arranged and supported installation.
- F. Cable Pulling Report: After cable installation, prepare and submit for approval a Cable Pulling Report documenting conditions during cable installation. Refer to Submittals Article, above, for documentation requirements.
- G. Bundle cable and conductors neatly and securely with nylon cable ties in branch circuit panelboards, cabinets and control boards. Bundle power cables separately from control cables.

3.6 SPLICES AND TERMINATIONS

- A. Use continuous lengths of wire and cable between power source and equipment. Splices are subject to approval by Engineer.
- B. Install splices and terminations in accordance with the cable and terminator manufacturers' instructions.
- C. Where splices are required and approved by Engineer, make them only in approved outlet, junction or pull boxes, or in equipment cabinets.
- D. Splice in multiconductor cables in accordance with the cable and splice-kit manufacturers' recommendations.
- E. Tools:
1. Use splice and terminator installation tools and installation techniques recommended by the manufacturer.
 2. Conductor sizes through No. 6 AWG: Mechanical hand tools may be used, with dies for each conductor size as recommended by the manufacturer.
 3. Conductor sizes larger than No. 6 AWG: Use hydraulic tools with hexagonal or circumferential dies as recommended by the manufacturer.
 4. Insulate splices to a level equal to that of the cable.
 5. Fixture Wire: Make splices in lighting circuits with insulated crimp-type connectors.
 6. Control and Switchboard Wires: Terminate each wire held with screw-type terminals using an insulated sleeve (nylon), ring-tongue-type or locking spade-type, crimp-on lugs.
- F. Torque bolted connections with a calibrated torque wrench to values specified in Section 26 05 00, Common Work Results for Electrical.

3.7 FIREPROOFING DC FEEDERS

- A. Provide fireproofing tape in manholes, handholes, cable vaults, switchgear, and where exposed in other locations.
- B. Tape each conductor individually.

- C. Conductors that make up a single circuit may be taped as a group in intermediate vaults only when all three of the following conditions are satisfied:
 - 1. The cables have twisted during installation such that it is impossible to tape each individual conductor.
 - 2. The cables are not spliced in the vault in question
 - 3. The Engineer agrees that it is impossible to tape each individual conductor at that location.
- D. Under no conditions shall conductors from different circuits be taped together as a group.

3.8 IDENTIFICATION

- A. Identify conductors cables at all terminal points and duct entrances at junction boxes, switches, circuit breakers, and pullboxes with tags as specified.
- B. Engineer will furnish cable numbering system.
- C. Wire sleeves: Print cable destination and number of conductors in cable as described in Contract Drawings.
- D. Wire and Cable tags: Attach with plastic tie wraps.

3.9 FIELD QUALITY CONTROL

- A. Cable Pulling Report: For installations where cable pulling calculations were required, provide cable tension measuring equipment and record the highest cable tension experienced during the installation. Submit Cable Pulling Report for approval.
- B. Wire and Cable Testing: Perform in compliance with Section 34 21 90, Traction Electrification System Testing.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 26 05 19 LOW-VOLTAGE CONDUCTORS AND CABLE

PART 1 - GENERAL

1.1 SUMMARY

- A. Low-voltage wire and cable.
- B. Dc traction power cable.
- C. Extra-flexible cable, bare and insulated.
- D. Wiring connections, splices, and terminations.

1.2 RELATED SECTIONS

- A. Section 26 05 00 – Common Work Results for Electrical
- B. Section 26 05 10 – Common Work Results for Systems Conductors and Cable
- C. Section 34 21 90 – Traction Electrification System Testing

1.3 DEFINITIONS

- A. Low-voltage cable: A single or multi-conductor insulated cable rated 2000 V or less.

1.4 REFERENCE STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents, or if standard is adopted by the City of El Paso, the latest revision adopted:
- B. ASTM International (ASTM)
 - 1. ASTM B3, Specification for Soft or Annealed Copper Wire
 - 2. ASTM B8 Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
 - 3. ASTM B33 Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes
 - 4. ASTM B172 Standard Specification for Rope-Lay-Stranded Copper Conductors Having Bunch-Stranded Members, for Electrical Conductors
 - 5. ASTM B496 Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors
 - 6. ASTM D747 Standard Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam
 - 7. ASTM D1000 Test Methods for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications
 - 8. ASTM D3005 Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape

- C. Insulated Cable Engineering Association (ICEA)
 - 1. ICEA S-95-658/NEMA WC 70 Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy
 - 2. ICEA T-29-520 Vertical Cable Tray Flame Tests @ 210,000 BTU
 - 3. ICEA T-30-520 Vertical Cable Tray Flame Tests @ 70,000 BTU
- D. Institute of Electrical and Electronics Engineers (IEEE)
 - 1. IEEE 383 Standard for Qualifying Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations
 - 2. IEEE 1202 Standard for Flame-Propagation Testing of Wire and Cable
- E. InterNational Electrical Testing Association, (NETA)
 - 1. ANSI/NETA ATS Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems
- F. International Organization for Standardization (ISO)
 - 1. ISO 9001 Quality Management Systems – Requirements
- G. National Electrical Contractors Association
 - 1. NECA 1 Standard Practices for Good Workmanship in Electrical Contracting
- H. National Fire Protection Association
 - 1. NFPA 70 National Electrical Code (with City of El Paso amendments)
- I. Underwriters Laboratories (UL)
 - 1. UL 44 Thermoset-Insulated Wires and Cables
 - 2. UL 1277 Electrical Power and Control Tray Cables with Optional Optical-Fiber Member
 - 3. UL 1581 Reference Standard for Electrical Wires, Cables, and Flexible Cords

1.5 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Submit Product Data on the following items:
 - 1. Wire and cable of each type.
 - 2. Splicing and terminating materials.
- C. Product information for each type and size of wire and cable shall include the following:
 - 1. Manufacturer of wire and cable, and certificate of compliance.
 - 2. Number and size of strands composing each conductor.
 - 3. Conductor insulation composition and thickness.
 - 4. Average overall diameter of finished wire and cable.
 - 5. Storage instructions.

6. Minimum training radius, in inches.
 7. Minimum insulation resistance in megohms per 1000 feet at 30 degrees C ambient.
 8. Jacket composition and thickness in mils.
 9. Total number of conductors per cable.
 10. Shield material (if any) and thickness.
 11. Conductor resistance in ohms per 1000 feet at 25 degrees C ambient.
 12. Conductor ampacity at 30 degrees C ambient for 600 V wire and cable.
- D. Submit Test Procedures and Test Reports:
1. Certified test reports for Design Tests, Production Tests, and Flame Tests.
 2. Test procedures, including details of proposed test equipment.
 3. Field Test Report, including the following:
 - a. Continuity test.
 - b. Phase test for three-phase circuits.
 - c. Insulation resistance test.
- E. As-built Drawings:
1. Submit as specified in Section 01 78 39, Project Record Documents.
 2. Show splices in low-voltage cable, where permitted by Engineer, on as-built drawings.

1.6 QUALITY ASSURANCE

- A. Qualifications: Cable manufacturer shall have a minimum of five years' experience successfully manufacturing the type of cable to be supplied by that manufacturer.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. See Section 26 05 10, Common Work Results for Systems Conductors and Cable.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Wire and Cable Marking: Verify that wire and cable markings comply with applicable NEMA and NFPA 70 requirements.

2.2 600 V SINGLE CONDUCTOR CABLE

- A. Conductor Material: ICEA stranded or solid copper meeting requirements of ASTM B3, soft drawn.
- B. Conductor Type:
1. Size 12 AWG and Smaller: Solid conductor.
 2. Size 10 AWG and Larger: Class B stranded.
- C. Insulation:

1. Size No. 14 to 1/0 AWG: Type XHHW-2, cross-linked polyethylene insulated in accordance with ICEA S-95-658/NEMA WC 70.
2. Size 2/0 AWG and Larger: Type XHHW-2, cross-linked polyethylene insulated in accordance with ICEA S-95-658/NEMA WC 70 or type RHH/RHW, ethylene-propylene-rubber-insulated in accordance with ICEA S-95-658/NEMA WC 70.
3. Voltage Rating: 600 V.
4. Temperature Rating: Insulation temperature rating not less than 90 degrees C in wet or dry locations.

2.3 600 V SWITCHBOARD WIRE

- A. Conductor: Stranded, tinned, annealed copper per ASTM B33.
- B. Insulation: Thermoset, chemically cross-linked polyethylene, UL Type SIS, 90 degrees C. Flame rated per UL 1581, Vertical Flame (VW-1).

2.4 2 KV SWITCHBOARD WIRE

- A. Conductor: Annealed, tinned copper per ASTM B33, flexible-stranded per ASTM B172.
- B. Insulation: Flame-retardant, crosslinked polyolefin, rated 2000 V, 110 C, 45 mil minimum thickness.
- C. Acceptable Manufacturer/Product: Rockbestos Exane-1068A, or approved equal.

2.5 2 KV SINGLE-CONDUCTOR DC FEEDER CABLE

- A. General:
 1. Type RHW-2, 90 degrees C, unshielded, size as indicated.
 2. Insulation and jacket system shall be rated for application up to 2 kV.
 3. Cable shall be suitable for use on service and feeders, indoors or outdoors, in wet or dry locations, or in raceway/duct. Cable shall be sunlight resistant and suitable for installation at 0 degrees C and in cable tray.
 4. Cables shall meet or exceed the requirements of ICEA S-95-658/NEMA WC 70, UL 44, and UL 1581.
 5. Cable shall be manufactured and tested under the control of a Quality Assurance program that meets the requirements of ISO 9001.
- B. Conductors: Annealed, uncoated copper, round or compact, concentric-lay stranded per ASTM B496.
- C. Insulation: Ethylene-propylene rubber (EPR) meeting electrical and physical requirements of ICEA S-95-658/NEMA WC 70.
 1. No polyethylene shall be allowed as a component of the insulation and EPR insulation shall be compounded by the cable manufacturer.
 2. For flexibility, the insulation compound shall have an Apparent Bending Modulus of 2600 psi or less in accordance with Standard Test Method ASTM D747.
- D. Overall Sheath Jacket: Thermosetting chlorinated polyethylene unless noted otherwise.
- E. Approved Manufacturer/Product: The Okonite Company, Okoguard-Okolon TS-CPE, or approved equal.

2.6 EXTRA-FLEXIBLE CABLE

- A. Conductor: Copper; Class I stranding, or as indicated; ASTM B3, ASTM B172; bare or insulated.
- B. Insulation:
 - 1. Type RHW-2, 90 degrees C, unshielded, rated 2 kV, size as indicated.
 - 2. Ethylene-propylene rubber (EPR) as specified above under 2 kV single-conductor cable.

2.7 MULTI-CONDUCTOR, LOW-VOLTAGE CABLE

- A. Provide multi-conductor cable conforming to ICEA S-95-658/NEMA WC 70, approved for use in cable tray, with the following additional requirements:
 - 1. Conductors: Bare, soft annealed copper per ASTM B33, Class B stranded in accordance with ASTM B8. Quantity of conductors as indicated.
 - 2. Insulation: As specified above for single conductor cable.
 - 3. Overall Covering: Cable shall be provided with sunlight-resistant jacket over the insulation meeting the flame-spread requirements of UL 1277.
 - 4. Multiple conductors for control wire shall be minimum of 14 AWG stranded copper.
 - 5. Insulation Rating: 600 V.
- B. Multi-conductor cable shall be made by assembling individual or twisted pairs of insulated conductors into a tight cylindrical form using fillers that are compatible with other materials in the cable. The jacket used shall fit tightly to form a firm assembly.

2.8 FIXTURE WIRE

- A. Provide fixture wire conforming to the following requirements:
 - 1. Type: SF-2 silicone rubber insulated.
 - 2. Conductor: Stranded copper conductor 16 AWG or larger as indicated.

2.9 BARE CONDUCTOR

- A. ASTM B3, Class B stranded, annealed soft-drawn copper conductor unless otherwise indicated. Size as indicated.

2.10 COLOR CODING OF CONDUCTORS (600 V)

- A. Identify individual conductors of multi-conductor cables by means of solid colors, stripes, or printing, unless otherwise approved by Engineer.
- B. Jacket Printing: Mark conductors in compliance with NFPA 70, and with the following additional information:
 - 1. Number of conductors (for multi-conductor cables).
 - 2. Date of manufacture.
- C. Footage Marker: Provide the following cable types with footage printing on the jacket or a footage marker tape under the jacket.
 - 1. Multi-conductor cables.

- D. Ac Power Cables: Conform to the following color coding for power cables:

<u>Conductor</u>	<u>480Y/277 V</u>	<u>208Y/120 V</u>
Phase A	Brown	Black
Phase B	Orange	Red
Phase C	Yellow	Blue
Neutral	White	White
Ground	Green	Green

- E. Use solid color insulation or solid color coating for branch circuit phase conductors No. 10 AWG and smaller and neutral and equipment ground conductors.
- F. Use a background color other than white or green for phase conductors with colored tracers.

2.11 FACTORY ASSEMBLY

- A. Wire and cable type requirements: See Section 26 05 10, Common Work Results for Systems Conductors and Cable.
- B. Circuit Separation: See Section 26 05 10, Common Work Results for Systems Conductors and Cable.
- C. Install wires and cables in accordance with manufacturer's recommendations and restrictions.
- D. Do not bend cables during installation, either permanently or temporarily, to radii less than 12 times the outer diameters, except where conditions make the specified radius impractical and shorter radii are permitted by the manufacturer.
- E. Bundle cable and conductors neatly and securely with cable ties in branch circuit panelboards, cabinets and control boards. Bundle power cables separately from control cables.
- F. Install wire and cable in conduit as indicated and in accordance with NECA 1.
- G. Terminations:
1. Use continuous lengths of wire and cable between power source and equipment. Splices are not permitted.
 - a. Tools:
 - b. Use terminator installation tools and installation techniques recommended by the manufacturer.
 - c. Conductor sizes through No. 6 AWG: Mechanical hand tools may be used, with dies for each conductor size as recommended by the manufacturer.
 - d. Conductor sizes larger than No. 6 AWG: Use hydraulic tools with hexagonal or circumferential dies as recommended by the manufacturer.
 - e. Use compression tools that permanently imprint die information on the completed connection.
 2. Control and Switchboard Wires: Terminate each wire held with screw-type terminals using an insulated sleeve (nylon), ring-tongue-type or locking spade-type, crimp-on lugs.
 - a. Current transformer secondary wiring shall use ring-tongue terminals only.
- H. Wiring Within Enclosures:
1. Requirements below apply to all electrical equipment enclosures, including junction boxes.

2. General:
 - a. Install wire as continuous lengths inside substations, without splices between terminations.
 - b. Wiring entering a removable enclosure shall be harnessed and secured to facilitate removal.
 - c. Wires from different wire runs shall not be harnessed together or with internal wiring.
3. Wire support:
 - a. Attach wiring within enclosures to conductor supports rigidly fastened to the enclosure structure.
 - b. Wiring supports shall be free from edges, bolt heads, or similar areas and shall not interfere with nor contact enclosure covers.
 - c. Secure wiring such that there is no strain on wire terminals, multi-pin connector pins, or other wire termination hardware.
 - d. Use of adhesive wire supports is not permitted.
4. Wire dress:
 - a. Allow sufficient slack at terminals to accommodate vibration, equipment shifting, cover removal, and component replacement.
 - b. Provide additional wire length for re-termination of wires without excess tension or splicing as follows:
 - 1) No. 10 and smaller: Three re-terminations.
 - 2) No. 8 and larger: Two re-terminations.
5. Terminal blocks: Provide with insulated covers.
6. Cubicle doors: Protect wires at hinges.

2.12 SOURCE QUALITY CONTROL

- A. Design Tests:
 1. 2 kV Single-Conductor Dc Feeder Cable:
 - a. Cable shall meet the requirements of the following flame test procedures:
 - 1) UL 44 vertical tray flame test.
 - 2) IEEE 1202 for 1/0 AWG & larger.
 - 3) IEEE 383.
 - 4) ICEA T-30-520 (70,000 BTU/hr.).
 - 5) ICEA T-29-520 (210,000 BTU/hr.) for #6 AWG & larger.
 2. Multi-Conductor 600 V Type TC Control Cable:
 - a. Flame Test: Completed cable shall pass the UL 1581 vertical tray flame test for cable assemblies.

B. Production Tests:

1. 2 kV single-conductor dc feeder cable: Perform on each reel of 2 kV single conductor dc feeder cable.
 - a. High voltage ac withstand test: Perform at the potential indicated in the table below after six hours immersion in water and while still submerged. Hold voltage for 5 minutes.

Conductor Size (AWG/kcmil)	Wall Thickness (min average)		Withstand Voltage (kVac)
	EPR	TS-CPE	
8-2	55	30	7.0
1-4/0	65	45	8.0
250-500	75	65	9.5
550-1000	90	65	11.5

- b. Insulation Resistance Test: The insulation resistance constant shall not be less than 15,000 megohms per1000 feet at 15.6 degrees C.
2. Submit certified test reports documenting production testing.

PART 3 - EXECUTION

3.1 FIELD INSTALLATION

- A. See Section 26 05 10, Common Work Results for Systems Conductors and Cable.

3.2 FIELD QUALITY CONTROL

- A. See Section 34 21 90, Traction Electrification System Testing, for field testing for wire and cable.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification
SECTION 26 05 26
GROUNDING AND BONDING

PART 1 - GENERAL

1.1 SUMMARY

- A. TPSS grounding.
- B. TPSS power system grounding, electrical equipment grounding, and raceway grounding.
- C. Requirements for substation ground bus.

1.2 RELATED SECTIONS

- A. Section 26 05 29 – Hangers and Supports
- B. Section 34 21 16 – TPSS Enclosures
- C. Section 34 21 90 – Traction Electrification System Testing

1.3 REFERENCE STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents, or if standard is adopted by the City of El Paso, the latest revision adopted:
- B. ASTM International (ASTM)
 - 1. ASTM B3, Specification for Soft or Annealed Copper Wire
 - 2. ASTM B187, Specification for Copper Bar, Bus Bar, Rod and Shapes
- C. Institute of Electrical and Electronics Engineers (IEEE)
 - 1. IEEE 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
 - 2. IEEE 837, Standard for Qualifying Permanent Connections Used in Substation Grounding
- D. National Fire Protection Association (NFPA)
 - 1. NFPA 70, National Electrical Code (with City of El Paso amendments)

1.4 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Product Data: Specified materials.
- C. Substation interior perimeter ground bus drawings:
 - 1. Provide plan view showing perimeter ground bus, equipment, and ground connections.
 - 2. Provide elevations of each wall showing height of perimeter ground bus and connections to equipment.

1.5 QUALITY ASSURANCE

- A. Regulatory Requirements:
 - 1. Unless otherwise specified, electrical equipment and material shall be listed and labeled for the purpose for which it is used, by the Underwriters Laboratories, Inc. (UL).
 - 2. Installations shall be in accordance with NFPA 70.
- B. Qualifications: Persons installing exothermic welds shall be trained in their installation.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Ship each item of equipment and materials securely wrapped, packaged, and labeled for safe handling in shipment and to avoid damage.
- B. Store equipment and materials in secure and dry storage facility.

PART 2 - PRODUCTS

2.1 EQUIPMENT AND MATERIALS

- A. Ground Rods:
 - 1. Copper-clad steel, non-rusting, sectional type.
 - 2. Size: Minimum 8 feet long and 3/4-inch diameter.
 - 3. Acceptable Manufacturer: Erico, or approved equal.
- B. Substation Ground bus:
 - 1. ASTM B187, 98 percent conductivity copper, silver plated.
 - 2. Size: 1/4-inch thick. Width depends on specific application (see Part 3, below).
- C. Stranded Bare Conductors: ASTM B3, Class B stranded, annealed copper conductor, unless otherwise indicated; size as indicated.
- D. Insulated Conductors: ASTM B 3, Class B stranded, annealed copper conductor, type XHHW-2 unless otherwise indicated, green colored, size as stated or indicated.
- E. Terminal Lugs: Exothermically-welded or compression-type approved for the application.
- F. Jumpers: Tin-plated copper, braided, flexible jumper.
- G. Compression Connections: Connectors and compression tools of a single manufacturer. Connectors shall have an inspection port for use in checking proper conductor insertion.
- H. Compression Tools: For field quality control, compression tools shall not release before completion of the compression cycle and shall emboss the die index number into the connector as the crimp is completed.
- I. Bolted connectors: Burndy, or approved equal.
- J. Bolts for attachment of lug to equipment: Bronze.
- K. Exothermic Welding System:
 - 1. Provide dual-component exothermic welds with molds and accessories of a single manufacturer.

2. Approved Manufacturers:
 - a. Erico;
 - b. Thermoweld; or approved equal.

2.2 FACTORY ASSEMBLY

A. Raceway Ground:

1. Assemble metallic conduits to provide a continuous ground path.
 - a. Bond metallic conduits using insulated grounding bushings.
 - b. Connect grounding bushings to the grounding system using conductors sized to comply with NFPA 70.
2. Equipment Ground: In metallic and nonmetallic conduits where conductors are installed, provide a separate equipment grounding conductor, sized to comply with NFPA 70, Article 250, and installed in accordance with these Specifications.

B. Equipment and Enclosure Grounds:

1. Connect electrical and distribution equipment to the grounding system. Size cables or bus as specified.
2. Connect non-electrical equipment with metallic enclosures to the grounding system.
3. Bond boxes to the raceway or conduit system with a copper jumper solidly bolted to the box, sized to comply with NFPA 70.

C. Equipment Grounding Requirements:

1. Install a copper equipment grounding conductor in each raceway and bond to metallic raceways and boxes at access and pull points.
2. Size equipment grounding conductors in accordance with NFPA 70 to provide adequate conduction path for ground faults. Increase size as required to allow for circuit voltage drop.
3. Ground metallic raceways, boxes, cabinets, exposed expansion joints, lighting fixtures, motors, transformers and receptacles. Provide grounding bushings or compression connectors attached with machine screws for bonding.

D. Substation Interior Perimeter Ground Bus:

1. Provide 2-inch wide ground bus around entire perimeter of substation interior.
 - a. Mount on framing channel. See Section 26 05 29, Hangers and Supports for Electrical Systems, for framing channel requirements.
 - b. Install at 18 inches above finished floor where there are no obstructions, and up to 8 feet above finished floor to avoid equipment or doorways.
2. Provide 1-inch wide ground bus from ac switchgear, ac surge arresters, panelboards, and other electrical equipment to perimeter ground bus.
3. Connect interior perimeter ground bus to four substation enclosure exterior grounding pads specified in Section 34 21 16, TPSS Enclosures.

PART 3 - EXECUTION

3.1 FIELD INSTALLATION

- A. Requirements of Article titled "Factory Assembly" apply to field installation.
- B. Buried or embedded connections:
 - 1. Exothermically welded or compression-type terminal lugs using materials qualified in accordance with IEEE 837.
 - 2. Bolted connections shall not be buried or embedded.
- C. Above-ground connections:
 - 1. Exothermically welded or compression-type terminal lugs using materials qualified in accordance with IEEE 837.
 - 2. Bolted connections are permitted only in secured locations not accessible to the public.
- D. Connections shall be made in accordance with the manufacturer's requirements.
- E. Clean ferrous structures and piping and coat with minimum 6 mils thick zinc-rich primer for a distance of 6 inches from the grounding attachment point.
- F. Do not bond buried metallic piping systems or structures to grounding electrode systems unless specifically directed.
- G. Provide continuous ground conductor or splice using connections qualified in accordance with IEEE 837.
- H. Provide waterstops on stranded, ground conductors where they enter a structure.

3.2 RACEWAY GROUND

- A. Metallic and nonmetallic conduit: Provide a separate ground wire sized in accordance with NFPA 70, 250.122, Size of Equipment Grounding Conductors.
- B. Equipment grounds shall not be installed in a raceway with dc positive feeders or dc negative returns.

3.3 TPSS PERIMETER GROUND GRID

- A. At the site for each traction power substation (TPSS), provide a ground grid as shown on Contract Drawings.
- B. Pre-test ground grid in accordance with Section 34 21 90, Traction Electrification System Testing, before pouring TPSS slab. If resistance is greater than 5 ohms, add additional ground rods until a resistance of 5 ohms or less is achieved.
- C. After delivery of each prefabricated TPSS by others, connect ground pigtailed from ground grid to substation-enclosure grounding pads at each of the four corners of the substation enclosure interior.
- D. Ground connections: Compression-type terminal lugs. Make connections in accordance with substation manufacturer's instructions.

3.4 TPSS INTERIOR PERIMETER GROUND BUS (BUILT-IN-PLACE TPSS)

- A. Provide 2-inch ground bus around entire perimeter of substation interior.
 - 1. Mount to wall on 13/16-inch deep framing channel, as specified in Section 26 05 29, Hangers and Supports for Electrical Systems.
 - 2. Install at 18 inches above finished floor where there are no obstructions, and up to 8 feet above finished floor to avoid equipment or doorways.
- B. Provide 1-inch ground bus from ac switchgear, ac surge arresters, panelboards, and other electrical equipment to perimeter ground bus.
- C. Connect perimeter ground bus to building ground system.

3.5 FIELD TESTING

- A. Test grounds in accordance with Section 34 21 90, Traction Electrification System Testing.
- B. Grounds shall not exceed the following maximum resistance:
 - 1. TPSS enclosure or building ground: 5 ohms.
 - 2. Surge arrester grounds: 5 ohms.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 26 05 29 HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Raceway and equipment supports.

1.2 RELATED SECTIONS

- A. Section 05 05 00 – Common Work Results for Metals
- B. Section 26 05 33 – Raceways and Boxes

1.3 REFERENCE STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents:
- B. ASTM International (ASTM)
 - 1. ASTM A123/A123M, Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
 - 2. ASTM F2329, Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners

1.4 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Product Data:
 - 1. Submit for each type of specified material proposed for use.
 - 2. Indicate the name of manufacturer, brand name, and catalog number for each type of material.

PART 2 - PRODUCTS

2.1 RACEWAY SUPPORTS

- A. Conduit clamps for individual conduit supports: One-hole, galvanized, heavy-gage steel, or galvanized malleable iron with clamp back.
- B. Channels, fittings and conduit racks: As specified in this Section.
- C. Straps and clamps: Listed for the task.

2.2 FRAMING CHANNEL AND FITTINGS

- A. Framing channel and channel fittings, clamps and accessories shall be hot-dip galvanized, or electro-galvanized and zinc chromate coated steel.
- B. Framing channel: 14-gage minimum, 13/16 inch or 1-5/8 inch-deep by minimum 1-5/8 inch-wide.

- C. Where heavy-duty racks are called out, framing channel shall be 12-gage, single or double 1-5/8 inch deep by 1-5/8 inch wide.
- D. Hanger rods: Galvanized steel or electro-galvanized and zinc chromate coated steel, 3/8-inch minimum.
- E. Prohibited: Aluminum, or light gage or strength metals or materials shall not be used.
- F. Acceptable Manufacturers:
 - 1. Unistrut;
 - 2. Powerstrut;
 - 3. Beeline;
 - 4. Steel City; or approved equal.

2.3 ANCHORS

- A. Anchor Rating: Sufficient strength to support four times the load.
- B. For metal, use machine screws, bolts, or welded studs with nuts and lockwashers.
- C. Prohibited: Powder driven anchors or studs shall not be used.

2.4 FASTENERS AND HARDWARE

- A. Fasteners and hardware shall be suitable for the use and environment intended.
 - 1. Fasteners shall be corrosion resistant.
 - 2. Plated steel fasteners: Use only indoors, in dry locations.
 - 3. Prohibited: Unplated steel shall not be used.
- B. Stainless steel fasteners shall be used in splice boxes which are exposed to weather, or in damp or wet locations.
- C. Bolted connections shall be made using lock washers.

2.5 CORROSION CONTROL

- A. Material and equipment shall be designed to ensure satisfactory operation and life in the environmental conditions that exist where the material or equipment is installed.
- B. Wherever "galvanized" or "hot-dip galvanized" is called out in this Section of the Specification, the material shall be coated in accordance with ASTM A123/A123M.
- C. For sheet steel, galvanneal finish complying with Section 05 05 00, Common Work Results for Metals is an acceptable alternative to hot-dip galvanizing if cut edges are protected from corrosion.
- D. Galvanized Steel Field Coating: Organic cold galvanizing coating as specified in Section 05 05 00, Common Work Results for Metals.

2.6 FACTORY ASSEMBLY

- A. Conduit Supports and Racks:
 - 1. Load Rating: Conduit supports shall be capable of supporting a load equal to the sum of the weights of the conduit, wire, and the hanger itself, plus 200 pounds.

2. Spare capacity: Minimum 25 percent.
 3. Multiple runs of exposed conduit: Group and support on conduit racks constructed from steel channels, conduit clamps and fittings.
 4. Vertical conduit racks: Provide supplementary bolted stop-blocks below each conduit clamp in a vertical strut to assure that clamps cannot slide down the channel.
 5. Multiple Conduits 2-inch or Larger: Support with heavy-duty channel, clamps and accessories.
 6. Individual Horizontal Conduits 2-inch or Larger: Support with individual hangers.
 7. Conduits 1-1/2 inch or smaller: Support with one-hole conduit straps with back spacers or individual conduit racks.
 8. Insulated: When conduit is within 18 inches above rectifier and dc switchgear, support with insulated materials.
 9. Make fittings up tight to prohibit movement, unless longitudinal movement is required due to conduit expansion.
- B. Cable Tray Supports:
1. Support in accordance with Section 26 05 33, Raceways and Boxes, using steel channels, threaded rods and hardware.
 2. Insulate cable tray supports where cable tray runs over rectifiers and dc switchgear and supports are within 18 inches of rectifier or dc switchgear.
- C. Fasteners and Hardware:
1. The material, coating and finish of fasteners and hardware shall be suitable for the environment and use intended.
 2. If fasteners or hardware exhibit corrosion, replace with a suitable type as directed by Engineer at no additional cost to the Owner.
- D. Damage Touch Up:
1. Apply to galvanized surfaces where required due to cutting of hanger rods or channel, or construction damage.
 2. Brush on a thick coat of cold galvanizing coating to cut ends. Coating may be sprayed on if at least three coats are applied.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Requirements of Article titled "Factory Assembly" apply to field installation.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 26 05 33 RACEWAY AND BOXES

PART 1 - GENERAL

1.1 SUMMARY

- A. Electrical conduit and ducts.
- B. Cable tray.
- C. Outlet, junction, and pull boxes.
- D. Electrical distribution cabinets.

1.2 RELATED SECTIONS

- A. Section 05 05 00 – Common Work Results for Metals
- B. Section 26 05 00 – Common Work Results for Electrical
- C. Section 26 05 26 – Grounding and Bonding
- D. Section 26 05 29 – Hangers and Supports for Electrical Systems
- E. Section 26 05 43 – Underground Ducts and Raceways for Electrical Systems

1.3 DEFINITIONS

- A. Raceway: As defined in NFPA 70, and products specified in this Section.

1.4 REFERENCE STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents, or if standard is adopted by the City of El Paso, the latest revision adopted:
 - B. American National Standards Institute (ANSI)
 - 1. ANSI C80.1, Standard for Electrical Rigid Steel Conduit (ERSC)
 - C. National Electrical Contractor's Association (NECA)
 - 1. NECA 1, Standard Practice of Good Workmanship in Electrical Contracting
 - D. National Electrical Manufacturers Association (NEMA)
 - 1. NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum)
 - 2. NEMA FG 1, Fiberglass Cable Tray Systems
 - 3. NEMA ICS 2, Industrial Control and Systems Controller, Contactors, and Overload Relays 600 V
 - 4. NEMA RN 1, Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
 - 5. NEMA TC 2, Electrical Polyvinyl Chloride (PVC) Conduit

6. NEMA TC 3, Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing
 7. NEMA TC 14, Reinforced Thermosetting Resin Conduit (RTRC) and Fittings
- E. National Fire Protection Association (NFPA)
1. NFPA 70, National Electrical Code (with City of El Paso amendments)
 2. NFPA 130, Fixed Guideway Transit and Passenger Rail Systems

1.5 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. List of Materials:
1. Submit a list of materials proposed for use.
 2. Give name of manufacturer, brand name, and catalog number of each item.
 3. Submit list complete at one time, with items arranged and identified in numerical sequence by Specification Section and Article number.
- C. Compliance with Applicable Standards:
1. Where equipment or materials are specified to conform to standards of organizations such as ANSI, ASTM, and NEMA, submit evidence of conformance. The label or listing of specified agency will be acceptable evidence.
 2. Instead of the label or listing, Contractor may submit a written certificate from an approved, nationally recognized testing organization, stating that items have been tested and units conform to specified standard.
- D. Shop Drawings:
1. Submit shop drawings showing exact location and arrangement of conduits, cabinets, and pullboxes installed under this Contract.
 2. Submit drawings with ample time to prevent delays in Work.

1.6 QUALITY ASSURANCE

- A. Qualifications:
1. Raceway installers shall be electricians licensed by the State.

PART 2 - PRODUCTS

2.1 CONDUIT AND FITTINGS

- A. Galvanized Rigid Steel (GRS) Conduit and Accessories: ANSI C80.1; hot-dip galvanized inside and out after threading; ensure each length bears UL label.
- B. GRS Fittings and Accessories:
1. Bushings: Nylon-insulated, metallic.
 2. Grounding bushings: Nylon-insulated, metallic, with lay-in lugs.

3. Sealing Bushings:
 - a. Galvanized malleable or ductile iron bushings with Bakelite sealing and pressure discs and individual neoprene cable rings.
 - b. Bushings shall seal ends of GRS conduit against the entrance of water, air or dust around emerging cables.
 - c. Approved Manufacturer/Product: O-Z/Gedney, type KR, or approved equal.
4. Conduit straps, clamps, and clamp backs: Galvanized malleable iron.
5. Vertical-Conduit Cable Supports:
 - a. Malleable or ductile iron body with hot-dip galvanized finish.
 - b. Non-metallic tapered wedging plug that supports cable without damaging insulation.
 - c. Weatherproof, ventilating type.
 - d. Acceptable Manufacturer/Product: O-Z/Gedney, type CMT, R-style, or approved equal.
- C. PVC-Coated GRS Conduit (PVC/GRS or PGRS): NEMA RN 1, with corrosion resistant internal coating.
- D. Reinforced Thermosetting Resin Conduit (RTRC): NEMA TC 14; standard or heavy-wall, UL listed.
 1. Conduit joints and fittings: Tapered or untapered; all of one type.
- E. PVC Electrical Conduit and Fittings:
 1. Conduit: NEMA TC 2, EPC-40-PVC or EPC-80-PVC; heavy wall, high impact strength, rigid PVC.
 2. Fittings: NEMA TC 3, EPC-40-PVC.
- F. Liquidtight Flexible Metallic Conduit and Fittings.
 1. Core: Flexible galvanized steel with a continuous copper bonding conductor spiral wound between the convolutions.
 2. Jacket: Extruded liquid-tight plastic or neoprene; moisture- and oil-proof, capable of conforming to the minimum radius bends of flexible conduit without cracking; self-extinguishing with low halogen containing material.
 3. Fittings: Zinc-coated.

2.2 OXIDE INHIBITING JOINT COMPOUNDS

- A. Petroleum-based compound with evenly suspended zinc particles.
- B. Approved Manufacturer/Product: Burndy, Penetrox A, or approved equal.

2.3 CABLE TRAY

- A. Type: Fiberglass, ladder or solid-bottom type with solid covers and other accessories, NEMA FG 1.
- B. Minimum Dimensions:
 1. Width: Minimum 6 inches.

2. Loading depth: Minimum 3 inches.
3. Inside nominal depth: Minimum 5 inches.
4. Radius of curved fittings: Minimum 24 inches unless otherwise approved by Engineer.

C. Performance Requirements:

1. 30 inch width or less: Capable of supporting a total cable load of 55 pounds per linear foot on a maximum span of 8 feet, including a 200-pound static load as specified below.
2. Over 30-inch width: Capable of supporting a total cable load of 88 pounds per linear foot on a maximum span of 8 feet including a 200-pound static load as specified below.
3. Requirements shall be independent of type of splice plates or type of span, when tested in accordance with load test procedure specified in NEMA standards.
4. Safety factor: 2, based on destructive load.
5. 200 pound static load: Straight sections and fittings shall not permanently deform under a 200 pound static concentrated load applied vertically along a 4-inch length for both of the following conditions:
 - a. Load applied to center of one tray section having specified cable load and support spacing.
 - b. Load shall be applied at midpoint between supports over a splice connection.
 - c. Load applied to one rung of empty tray section having specified support spacing. Load shall be located at midpoint between side rails and supports.

2.4 CONDUIT HANGERS AND SUPPORTS

- A. Refer to Section 26 05 29, Hangers and Supports for Electrical Systems.

2.5 OUTLET, JUNCTION, AND PULL BOXES

- A. Sheet metal outlet boxes: Steel, galvanized.
- B. Sheet metal junction and pull boxes: Galvanized or stainless steel, hinged or screw-cover with stainless steel screws.
- C. Cast metal boxes: Hot-dip galvanized inside and out.
1. Blank covers: Same thickness as boxes and secured with No. 10-24 stainless steel machine screws.
 2. Device covers: See Section 26 05 00, Common Work Results for Electrical.
 3. Neoprene gaskets: 1/8-inch thick.
- D. Nonmetallic boxes: Heavy duty, phenolic, surface-mounted, with threaded nonmetallic conduit hubs, type FD, single- or double-gang as required. Provide non-metallic device covers.
1. Acceptable Manufacturer/Product: Thomas & Betts, Carlon FSC-34, or approved equal.

2.6 ELECTRICAL CABINETS

- A. NEMA 1, 12, 4X, or as indicated.
- B. Galvanized or stainless steel, size as noted on Contract Drawings.
1. Fronts: Steel.

2. Mounting: Surface or recessed type as required for the application.
 3. Hinges: Continuous, stainless steel.
 4. Locks: Provide flush locks from a single manufacturer with standard key blank; field-keyable.
 5. Finish: Powder coat, as specified in Section 05 05 00, Common Work Results for Metals.
 6. Cabinet back panel: white, galvanized steel interior mounting panel suitable for mounting terminal blocks and relays.
- C. Fiberglass composite:
1. Covers: Fiberglass.
 2. Hinges: Continuous, stainless steel.
 3. Surface: Smooth, no color variations, swirls, color pockets, or voids.

2.7 FACTORY ASSEMBLY

- A. See Part 3, below, for type requirements.
- B. Conduit:
1. General:
 - a. Install electrical raceway, boxes and accessories in locations as indicated, in accordance with NFPA 70, NECA 1, local codes and ordinances, and as indicated to provide a complete and operable system.
 - b. Where a conduit type indicated on Contract Drawings is in conflict with this Section, refer discrepancy to Engineer.
 2. Conduit threading:
 - a. Clean threads with a solvent recommended by coating manufacturer to remove oil.
 - b. Coat threads with organic cold galvanizing coating, in accordance with manufacturer's instructions.
 - c. If spray application is used, provide at least three coats.
 3. Metal-to-metal threaded joints:
 - a. Coat threads with oxide inhibiting compound.
 - b. Take care that compound is not present on interior of conduit after installation.
 4. Conduit caps:
 - a. Provide threaded cap or similar closure designed for the purpose on conduits that are not terminated immediately.
 - b. Prohibited: Tape is not acceptable for temporary cap.
 5. Conduit sealing:
 - a. Conduit exposed to different temperatures: Seal conduit to prevent condensation and passage of air from one area to the other.
 - b. Where waterproofing is required, seal conduits with watertight duct sealing system.

6. Liquid tight flexible metal conduit:
 - a. Install so that liquids tend to run off surface and do not drain toward fittings.
 - b. Provide sufficient slack to reduce the effects of vibration.
- C. Conduit Grounding and Bonding:
 1. Install metallic conduits to be electrically and mechanically continuous and connected to ground by bonding to the grounding system.
 2. See Section 26 05 26, Grounding and Bonding, for additional requirements.
- D. Conduit terminations:
 1. Dry areas:
 - a. Provide two locknuts, one inside and one outside of box or enclosure, for rigid conduit terminating at steel box, panelboard, cabinet, or similar enclosure.
 - b. Provide insulating bushing or grounding bushing on conduit end.
 2. Exposed, damp and wet locations: Provide threaded, water-tight hubs with sealing o-rings for cabinet connections or threaded connections to tapered threaded hubs for cast boxes and fittings.
 3. Terminate the conduit in appropriate boxes at motors, switches, outlets, and junction points.
- E. Cable Tray:
 1. General:
 - a. Install cable trays using approved fittings and adequately support the complete system. See 26 05 29, Hangers and Supports for Electrical Systems.
 - b. Install cable trays parallel to each other and the building and plumb and level.
 - c. Support cable trays with wall brackets or ceiling-mounted supports from the prefabricated building structure, with anti-sway brackets or braces where necessary.
 - d. Trays shall be located no closer than 2-1/2 inches from the nearest wall, unless otherwise approved.
 2. Supports:
 - a. Finish: Hot-dip galvanized after fabrication.
 - b. Ceiling supports: See Section 26 05 29, Hangers and Supports for Electrical Systems.
 - c. End supports: Support terminating sections of cable tray not more than 12 inches from end of tray.
 - d. Wall supports: Capable of sustaining an end-load of 1,600 pounds.
 - e. Spacing:
 - 1) Supports: Space at maximum distance of 5 feet to provide rigidity and adequate strength to support weight of trays and cables.
 - 2) Splices: Each tray splice shall have a support between 6 inches and 24 inches from the splice.

3. Seismic bracing: Provide bracing for cable tray system complying with sealed seismic calculations required in Section 26 05 00, Common Work Results for Electrical.
 4. Fasteners:
 - a. Solidly bolt trays to supporting channels using countersunk machine screws, 1/4 inch by 20 threads per inch, minimum.
 - b. After installation of fasteners, tray shall be free from burrs or sharp edges.
 5. Separators: Provide separators to isolate cables of different voltages.
- F. Boxes:
1. General:
 - a. Provide electrical boxes and cabinets of the material, finish, type, and size indicated and as required for the location, kind of service, number of wires, and function.
 - b. Ensure boxes and support fittings are of suitable and compatible materials that will not corrode when subjected to moisture or standing water.
 - c. Provide brackets, supports, hangers, fittings, bonding jumpers, and other installation accessories as required. Refer to Section 26 05 29, Hangers and Supports for Electrical Systems.
 - d. Securely attach outlet, junction, and pull boxes to the structure. Do not use conduits entering the box as supports for the box.
 2. Covers:
 - a. Provide boxes complete with accessible covers designed for quick removal and suitable for the purpose for which they will be used.
 - b. Provide flat or raised blank covers for boxes without devices or fixtures.
 - c. Provide neoprene gaskets for boxes subjected to weather.
 3. Installation:
 - a. Mount outlet, junction, and pull boxes so as to prevent moisture from entering or accumulating within the boxes.
 - b. Junction and Pull Boxes: Install so that covers are readily accessible after completion of the installation.
 4. Grounding: Ground/bond each box and cabinet as specified in Section 26 05 26, Grounding and Bonding.
 5. Dc equipment: For areas within 6 feet of dc rectifier and dc circuit breaker enclosures provide nonmetallic pull-boxes, junction boxes, device boxes, and covers.

PART 3 - EXECUTION

3.1 RACEWAY TYPE REQUIREMENTS

A. Permitted Conduit Types:

1. Underground – General:
 - a. PVC/GRS conduit.
 - b. PVC Schedule 40 or standard-wall fiberglass conduit encased in concrete structures or ductbanks.
 - c. Heavy-wall fiberglass conduit.
2. Underground – Exceptions:
 - a. EPE services: In accordance with EPE standards or as directed by EPE engineer.
3. Transition between embedded conduit and above-ground metallic conduit: PVC/GRS.
 - a. Ensure that above-ground PVC/GRS extends minimum 1 foot above ground or to conduit termination, whichever is less.
4. Conduits in traction power substations:
 - a. GRS or epoxy fiberglass.
 - b. Within 6 feet of dc rectifier or distribution breaker enclosures: Fiberglass.
5. Liquid-tight flexible metal conduit:
 - a. Permitted only where required for flexibility such as connections to vibrating equipment and across joints subject to differential movement.
 - b. Not acceptable as a substitute for other conduit types in areas with complicated bending requirements.
6. Conduit or raceway types not specifically called out in these Specifications or Contract Drawings shall not be used.

B. Permitted Cable Tray Type: Fiberglass with insulating support hardware.

C. Prohibited Raceway Types:

1. Wiring gutters or wireways.
2. Electrical Metallic Tubing (EMT).
3. Intermediate Metal Conduit (IMC).
4. Flexible metal conduit.
5. Conduit running thread.

3.2 CONDUIT MINIMUM SIZES:

- A. GRS: 3/4-inch.
- B. Fiberglass Conduit: 3/4-inch.
- C. Liquid-tight Flexible Metallic Conduit: 1/2-inch.

3.3 RACEWAY BENDS

- A. Minimum Bend Radius (above grade): In accordance with NFPA 70 Chapter 9 Table 2, "Other Bends" column.
- B. Refer to Section 26 05 43, Underground Ducts and Raceways for Electrical Systems, for bending requirements for underground ducts.

3.4 BOX AND CABINET TYPE REQUIREMENTS

- A. Dry locations:
 - 1. Outlet boxes: Sheet metal outlet boxes.
 - 2. Junction or pull boxes with volume less than 100 inches: Sheet metal junction or pull box.
 - 3. Cabinets: Galvanized steel, NEMA 250 Type 1.
- B. Damp locations:
 - 1. Outlet, junction, and pull boxes: Cast metal boxes.
 - 2. Cabinets: NEMA 250 Type 4X stainless steel unless otherwise approved.
- C. Within 6 feet of dc switchgear:
 - 1. Cabinets: Fiberglass composite.

3.5 INSTALLATION

- A. Requirements of Article titled "Factory Assembly" apply to field installation.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 26 05 43 UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Raceways installed underground.
- B. Concrete encasement of raceways in underground ductbanks.
- C. Precast concrete electrical boxes, pullboxes, and vaults.

1.2 RELATED SECTIONS

- A. Section 26 05 10 – Common Work Results for Systems Conductors and Cable
- B. Section 26 05 33 – Raceway and Boxes
- C. Texas Department of Transportation Standard Specifications Item 400, Excavation and Backfill for Structures

1.3 DEFINITIONS

- A. Raceway: As defined in Section 26 05 33, Raceway and Boxes.

1.4 REFERENCE STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents, or if standard is adopted by the City of El Paso, the latest revision adopted:
 - B. American Association of State Highway and Transportation Officials (AASHTO)
 - 1. AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specifications
 - C. ASTM International (ASTM)
 - 1. ASTM C33/C33M, Standard Specification for Concrete Aggregates
 - D. National Fire Protection Association (NFPA)
 - 1. NFPA 70, National Electrical Code (with City of El Paso amendments)

1.5 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. List of Materials: Submit a list of materials proposed for use. Give name of manufacturer, brand name, and catalog number of each item. Submit list complete at one time, with items arranged and identified in numerical sequence by Specifications Section and Article numbers.
- C. Compliance with Applicable Standards:
 - 1. Where equipment or materials are specified to conform to standards of organizations such as ANSI, ASTM, and NEMA, submit evidence of conformance. The label or listing of specified agency will be acceptable evidence.

2. Instead of the label or listing, Contractor can also submit a written certificate from an approved, nationally recognized testing organization, stating that items have been tested and units conform to specified standard.
- D. Shop Drawings.
1. Submit shop drawings showing exact location and arrangement of raceways and vaults installed under this Contract. Submit drawings with ample time to prevent delays in Work.

1.6 QUALITY ASSURANCE

A. Qualifications:

1. Raceway installers shall be electricians licensed by the State of Texas.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Raceways: In accordance with Section 26 05 33, Raceways and Boxes for Electrical Systems.
- B. Precast Concrete Electrical Boxes, Pullboxes, and Vaults:
1. Steel reinforced, of the type and size indicated on Contract Drawings.
 2. Complete with C channel to support cable racks.
 3. Load Rating: HS20.
 4. See Section 26 05 10, Common Work Results for Systems Conductors and Cable, for cable rack requirements.
- C. Ductbank Encasement:
1. Concrete:
 - a. 3000 pounds per square inch (PSI) with 4-inch slump.
 - b. Red concrete: As specified above but with 100 pounds of iron oxide per 8 cubic yards of concrete.
 2. Sand: Clean, graded, washed, passing a No. 4 U.S. sieve, and conforming generally to ASTM C33/C33M for fine aggregate.
 3. Warning tape:
 - a. Heavy gage, yellow, plastic for direct burial, material resistant to corrosive soil, 6-inch minimum width, minimum 4 mils thick.
 - b. Printed with warning that an electrical circuit is located beneath the tape.

PART 3 - EXECUTION

3.1 RACEWAY TYPE REQUIREMENTS

- A. See requirements for underground conduits in Section 26 05 33, Raceway and Boxes.

3.2 RACEWAY SIZE REQUIREMENTS

- A. Conduit Minimum Sizes:
 - 1. Underground conduit: 1-inch.
- B. Conduit Bends:
 - 1. Minimum Bend Radius:
 - a. Less than 2-inch conduit: In accordance with NEC Chapter 9 Table 2, "Other Bends" column.
 - b. 2-inch conduit: 24 inches.
 - c. Greater than 2-inch conduit: 36 inches.

3.3 INSTALLATION

- A. Excavation, Trenching, and Backfill: As indicated on Contract Drawings and specified in Texas Department of Transportation Standard Specifications Item 400, Excavation and Backfill for Structures.
- B. Ductbanks:
 - 1. Group conduits together to form a ductbank as indicated on Contract Drawings.
 - 2. Routing of ductbanks and conduits is indicated diagrammatically. Actual route must conform to field conditions.
 - 3. Install conduit runs with not more than 270 degrees total bends between pull boxes. Where more bends are required in a particular run, install pull boxes as required to facilitate pulling conductors, even if not indicated.
 - 4. Inspect conduit and couplings to ensure that only clean and undamaged pieces are used in the work.
 - 5. Install ducts, joints, and space separators according to manufacturer's printed instructions and recommendations.
 - 6. Install ductbanks or conduits with a minimum slope of 3 inches to each 100 feet away from buildings and towards manholes, pull boxes, and handholes.
 - 7. Terminate conduits and ducts in end-bells in vaults.
- C. Concrete Placement:
 - 1. Provide minimum 3-inch concrete on each side.
 - 2. Place concrete for each ductbank in one continuous pour.
 - 3. Maximum vertical drop: 3 feet, to prevent segregation of concrete. If drop greater than 3 feet is necessary, use a deflection board or other means approved by the Engineer to minimize direct vertical fall of the concrete.
 - 4. As concrete is deposited, mechanically vibrate the concrete continuously to eliminate voids and consolidate it around the reinforcing steel and conduits. Do not over vibrate.
- D. Protection:
 - 1. When installation of conduits is temporarily suspended or terminated, close ends of ducts with caps or plugs to prevent entry of water or debris.

2. Use caps or plugs designed for that purpose by the conduit manufacturer. Tape shall not be used for capping conduits.
- E. Mandrelling and brushing:
1. Notify the Engineer before mandrelling conduits.
 2. As each section of a ductbank is completed between manholes, handholes, or pull boxes, test with a mandrel that complies with Section 26 05 10, Common Work Results for Systems Conductors and Cable.
 3. Draw mandrel and brush through the conduit until conduit is clear of dirt and debris.
 - a. Install caps or plugs immediately after mandrelling and brushing.
- F. Precast Concrete Structures:
1. Install precast electrical boxes, pull boxes, handholes, manholes, and vaults as indicated on Contract Drawings.
 2. Place boxes on 4 inches of compacted sand bedding.
 3. Place manholes on compacted crushed rock base, as indicated on Contract Drawings.
 4. Seal unused openings with cement mortar.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification
SECTION 26 12 16
DRY-TYPE TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Low voltage two-winding dry-type transformers.
- B. Refer to Section 34 21 23, Transformer-Rectifier Unit for traction power transformer requirements.

1.2 RELATED SECTIONS

- A. Section 05 05 00 – Common Work Results for Metals
- B. Section 26 05 00 – Common Work Results for Electrical
- C. Section 26 24 13 – Switchboards
- D. Section 34 21 23 – Transformer-Rectifier Unit
- E. Section 34 21 80 – TES Spare Parts and Special Tools

1.3 REFERENCE STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents, or if standard is adopted by the City of El Paso, the latest revision adopted:
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. IEEE C57.12.01, General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid-Cast and/or Resin Encapsulated Windings
- C. National Electrical Manufacturer's Association (NEMA):
 - 1. NEMA TP 1, Guide for Determining Energy Efficiency for Distribution Transformers
- D. National Fire Protection Association (NFPA)
 - 1. NFPA 70, National Electrical Code (with amendments by the Authority Having Jurisdiction)

1.4 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Product Data: Submit manufacturer's product data of manufactured materials and equipment including the following:
 - 1. Outline and support point dimensions of enclosures and accessories.
 - 2. Unit weights.
 - 3. Voltage, kVA and impedance ratings and characteristics.
 - 4. Loss data.
 - 5. Efficiency at 25, 50, 75 and 100 percent rated load.
 - 6. Sound level.

7. Tap configuration.
 8. Insulation system type and rated temperature rise.
- C. Spare Parts and Special Tools:
1. Submit a list of spare parts to be provided under this Section.
 2. Submit at the same time as product data.
 3. Provide part numbers for each part, including a detailed break down of each spare part assembly and set, as defined in Section 34 21 80, TES Spare Parts and Special Tools.
- D. Sizing Calculations: Submit calculations for sizing of the Station Service Transformer. Allow for 50 percent additional future load. At a minimum, the transformer shall be rated 25 kVA.
- E. Operation and Maintenance Data:
1. Submit manufacturer's operating and maintenance instructions on products specified in this Section.
 2. Submit immediately after approval of product data.

1.5 SPARE PARTS

- A. Submit spare parts in accordance with Section 34 21 80, TES Spare Parts and Special Tools.
- B. List below applies to items in this Specification Section:
1. Station service transformer: Provide 1 spare of each size.

PART 2 - PRODUCTS

2.1 DRY TYPE TWO-WINDING TRANSFORMERS

- A. Dry Type Transformers: IEEE C57.12.01; factory-assembled, air cooled dry type transformers; ratings as shown on Contract Drawings.
- B. Insulation system and average winding temperature rise for rated kVA as follows:
1. 1 to 15 kVA: Class 185 insulation, 80 degrees C rise.
 2. 16 to 500 kVA: Class 220 insulation, 115 degrees C rise.
- C. Load Ratings and Transformer Cooling: Load ratings, unless noted otherwise, are assumed to be AA (air convection cooling). Windings: Copper primary and secondary.
- D. Winding Taps:
1. Transformers Less than 15 kVA: Two 5 percent, full-capacity taps below rated voltage on primary winding.
 2. Transformers larger than 15 kVA and smaller than 500 kVA: Two 2.5 percent full-capacity taps above rated voltage and four 2.5 percent full-capacity taps below rated voltage on primary windings.
- E. Energy Efficiency: NEMA TP 1.
- F. Sound Levels: Shall not exceed the following when tested according to IEEE C57.12.91.
1. 10 to 50 kVA: 45 dB.

2. 51 to 150 kVA: 50 dB.
 3. 151-300 kVA: 55 dB.
 4. 301 to 500 kVA: 60 dB.
- G. Basic Impulse Level:
1. Low-Voltage Dry-Type Transformers:
 - a. Transformers less than 300 kVA: 10 kV.
 - b. Transformers 300 kVA and larger: 30 kV.
- H. Ground core and coil assembly to enclosure by means of a visible, flexible copper grounding strap.
- I. Mounting:
1. 75 kVA and less: Suitable for wall, floor, or trapeze mounting, or mounting internal to switchgear.
 2. Larger than 75 kVA: Suitable for floor or trapeze mounting.
- J. Coil Conductors: Continuous windings with terminations brazed or welded.
- K. Enclosure:
1. Construction: Heavy gage sheet steel, ventilated.
 2. Type:
 - a. Indoor: NEMA Type 1.
 - b. Outdoor: NEMA Type 3R.
 3. Finish: Powder coat complying with Section 05 05 00, Common Work Results for Metals.
 4. Standards compliance: NEMA 250, NFPA 70, IEEE C57.12.01.
 5. Enclosure requirements do not apply to transformer located within ac switchgear cubicle, as indicated on Contract Drawings
- L. Isolate core and coil from enclosure using vibration-absorbing mounts.
- M. Nameplate: Include transformer connection data.

2.2 STATION SERVICE TRANSFORMER

- A. Calculate size of the Station Service Transformer as follows:
1. Calculate load per NFPA 70 based on heating, cooling, lighting, and other loads.
 2. Allow for 50 percent additional future load.
 3. At a minimum, the transformer shall be rated 25 kVA.
 4. Provide primary fused disconnect and secondary circuit breaker complying with NFPA 70.

2.3 FACTORY ASSEMBLY

- A. Install transformers plumb and level.
- B. Use copper bus for both primary and secondary connections.
- C. Mount transformers inside substation on vibration isolating pads suitable for isolating the transformer noise from the structure.
- D. Provide restraints for vertical and horizontal seismic motion in accordance with the seismic requirements in Section 26 05 00, Common Work Results for Electrical.
- E. Station Service Transformer: Mount inside ac switchboard enclosure, as described in Section 26 24 13, Switchboards. No station service transformers are required for built-in-place substations.

PART 3 - EXECUTION

3.1 FIELD INSTALLATION

- A. Requirements of Article titled "Factory Assembly" apply to field installation.

3.2 FIELD QUALITY CONTROL

- A. Check for damage and tight connections before energizing transformer.
- B. Measure primary and secondary voltages and make appropriate tap adjustments.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 26 24 13 SWITCHBOARDS

PART 1 - GENERAL

1.1 SUMMARY

- A. Switchboard for service and power distribution in traction power substation.
- B. Protective relays.
- C. Meters and current transformers.

1.2 RELATED SECTIONS

- A. Section 05 05 00 – Common Work Results for Metals
- B. Section 26 05 00 – Common Work Results for Electrical
- C. Section 26 12 16 – Dry Type Transformers
- D. Section 34 21 90 – Traction Electrification System Testing

1.3 REFERENCE STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents, or if standard is adopted by the City of El Paso, the latest revision adopted:
- B. ASTM International (ASTM)
 - 1. ASTM A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
- C. Institute of Electrical and Electronics Engineers (IEEE)
 - 1. IEEE C57.13, Standard Requirements for Instrument Transformers
- D. National Electrical Contractors Association (NECA)
 - 1. NECA 400, Standard for Installing and Maintaining Switchboards
- E. National Electrical Manufacturer's Association (NEMA)
 - 1. NEMA AB1, Molded-Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures
 - 2. NEMA PB 2, Deadfront Distribution Switchboards
- F. National Fire Protection Association (NFPA)
 - 1. NFPA 70, National Electrical Code (with City of El Paso amendments)

1.4 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Product Data:
 - 1. Submit manufacturers' product data for specified equipment and materials. Include the following information for each item:
 - a. Manufacturer's model number or item identification.
 - b. UL listing and rating.
 - c. Critical dimensions and mounting arrangement.
 - d. Replacement parts list.
- C. Shop Drawings:
 - 1. Show materials and methods of construction, door arrangement, conduit hubs and knockout locations.
 - 2. Circuit Breakers: Show circuit for which intended, voltage ratings, insulation level, current rating and interrupting ratings.
 - 3. Single line diagrams.
 - 4. Physical arrangement drawings and weight of equipment and major components.
 - 5. Unit wiring diagrams.
 - 6. Circuit breakers, controls and indications.
 - 7. Show space available for conduit and bus duct entrance and for routing and training of cables.
 - 8. Schematic diagrams for electrically operated equipment.
 - 9. Setting diagrams and templates if anchoring in concrete is required.
 - 10. Assembly and erection diagrams if shipped in sections or if some parts are shipped separately and not installed at the factory.
 - 11. Interconnection diagrams for circuits having externally located instruments, controls, alarms, or similar devices.
- D. Calculations: Submit sizing calculations for protection current transformers and metering current transformers. Obtain Engineer's approval before procuring current transformers.
- E. Testing:
 - 1. Submit test procedures that meet the requirements of Section 34 21 90, Traction Electrification System Testing, for the following:
 - a. Factory Design Tests.
 - b. Factory Production Tests.

2. Submit test reports that meet the requirements of Section 34 21 90, Traction Electrification System Testing, for the following:
 - a. Factory Design Tests.
 - b. Factory Production Tests.
- F. Operation and Maintenance Data:
 1. Submit manufacturer's operating and maintenance instructions on products specified in this Section.
 2. Submit immediately after approval of product data.

1.5 QUALITY ASSURANCE

- A. Qualifications: Manufacturer that has been regularly engaged in the manufacture of similar equipment and meets UL requirements.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Shipping:
 1. If approved by the Engineer, switchboards may be broken down into convenient shipping sections after tests are completed.
 2. Shipping split terminals and connections disconnected for shipping shall be properly identified and protected.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Metal-enclosed, self-supporting, dead front, freestanding, circuit-breaker type for indoor service.
- B. Comply with NEMA PB 2, NFPA 70, as applicable.
- C. Each item shall be UL labeled.
- D. Provide the required number of vertical sections designed for bolting together to form a rigid switchboard.
- E. Switchboards shall be assembled, wired and tested at the manufacturer's plant.
- F. Components of the same type, size, rating, functional characteristics and manufacture shall be interchangeable.

2.2 RATINGS

- A. Current rating: Based on operation in a 25 degree C room ambient.
- B. Bus bracing: 100 kA RMS momentary.

2.3 ENCLOSURE

- A. Type:
 1. Freestanding, reinforced with adequate steel framework to form a rigid structure
 2. Designed for group assembly as part of complete switchgear.

- B. Physical Size:
 - 1. Maximum 90 inches high.
 - 2. Width and depth adequate to accommodate and connect the equipment.
 - 3. Adequate space to accommodate bending radius requirements of cables.
- C. Material: Zinc-coated steel sheet conforming to ASTM A 653/A 653M, zinc coating designation G90.
- D. Workmanship: Fabricate with a smooth outer surface free from burrs, ridges and other blemishes.
- E. Finish:
 - 1. Powder coat as specified in Section 05 05 00, Common Work Results for Metals.
 - 2. Color: Refer to Section 05 05 00, Common Work Results for Metals.
- F. Configuration: Align vertical sections front and rear.
- G. Barriers: Switchboards in the same line-up fed electrically from different feeders shall have barriers such that a fire caused by an internal fault at one switchboard shall not spread to another switchboard.
- H. Doors: Equip with front and rear doors, except for built-in-place substations, where there will be no rear access and no station service transformers.
- I. Station Service Transformer:
 - 1. Provide adequate space in rear of enclosure to accommodate station service transformer. For information on transformer, see Section 26 12 16, Dry Type Transformers.
 - 2. Provide front or rear access to transformer.
- J. Mimic bus: Provide on front of each switchboard section.
 - 1. Factory-applied, plastic, 3/8-inch wide, minimum 1/32-inch thick.
 - 2. Color: Red.
- K. Nameplates:
 - 1. Provide a nameplate on each switchboard and its components as specified in Section 26 05 00, Common Work Results for Electrical.
 - 2. Label each control switch and pilot light with one inch wide nameplate showing the function and the number of unit in 1/2-inch high letters.

2.4 SWITCHBOARD BUSES

- A. Bus: Silver-plated copper buses of sufficient size to limit the current density to 750 A per square-inch cross section.
- B. Main Buses:
 - 1. Extend main buses horizontally from the incoming line sections to all distribution sections if indicated on the same line-up.
 - 2. Make provision for extending the main buses for future vertical sections.
- C. Section Buses: Extend section buses vertically from the main bus through each vertical section.

- D. Neutral bus: Fully rated.
- E. Ground Buses:
 - 1. Extend a ground bus through the length of the switchboard.
 - 2. Firmly bolt to each vertical section in at least two places.
 - 3. Make provision for connection to the building or station grounding system near each end of the ground bus.
 - 4. Make provision for future extension of the ground bus.
- F. Phasing: Phase buses A-B-C from left-to-right, top-to-bottom and front-to-rear as viewed from the front of the switchboard.

2.5 SWITCHBOARD CIRCUIT BREAKERS

- A. Type: Draw-out, insulated-case, stored energy, electrically operated, three phase, 60 Hz, in accordance with NEMA AB 1.
- B. Closing time: Maximum five cycles.
- C. Insulation rating of plug shall be the same as the breaker rating.
- D. Circuit breakers shall be capable of performing 4,000 close-open cycles at rated load, 80 percent power factor and rated voltage and 4,000 close-open cycles at no load without maintenance or replacement of parts.
- E. Breakers shall have control power and motor charging device of 125 Vdc.
- F. Breakers shall be equipped with field-replaceable contacts.

2.6 PROTECTIVE RELAYS

- A. Provide multifunction relays for each breaker and with voltage and current sensors as indicated on Contract Drawings.
 - 1. Device Functions:
 - a. Undervoltage 27
 - b. Overvoltage 59
 - c. Phase Balance 47
 - d. Instantaneous Overcurrent 50/50N
 - e. Time Overcurrent 51/51N
 - f. Control switch 43
 - 2. Features:
 - a. Panel Mount form factor
 - b. Ethernet over Fiber
 - c. Modbus TCP
 - d. USB port for programming
 - e. Alarm output contact for Monitoring by the SAS

3. Monitor the status of the multifunction relay from the SAS
 4. Communicate each device function to the SAS alarm panel.
 5. Relay must connect to the SAS using Ethernet over fiber.
 6. Approved Manufacturer: Basler BE1-11f or approved equal
- B. Lockout (Device 86):
1. Provide on the ac circuit breaker compartment.
 2. Lockout relay reset switch:
 - a. Handle type: Heavy-duty, rotary pistol-grip.
 - b. Contacts:
 - 1) Silver-to-silver.
 - 2) Enclosed, with easily removable covers.
 - 3) Current rating: Based on continuous, inrush, or interrupting requirements for the duty category and then derated by at least a factor of four.
 - 4) Voltage rating: Minimum of twice the applied voltage.
 - c. Actuating contacts: Use a cam action or similar positive means.
 - d. Escutcheon plate: Provide with each switch.
 - e. Switch positions: "LOCKOUT" and "RESET" with a spring return to center.
 3. Provide indication of "lockout" and "normal" at the reset switch, as described in this Section.
 - a. When the main ac circuit breaker for traction power substations is tripped by the lockout relay, the ac breaker shall be locked out until manually reset.
- C. Provide other protective relaying functions as indicated on one-line diagram in Contract Drawings.
- D. Trip Circuit Monitors:
1. Provide a trip circuit monitor for monitoring the trip coil on each of the following:
 - a. Main ac circuit breaker for traction power substations.
 - b. Lockout relay.
 2. Provide the following:
 - a. Green LED that illuminates when the trip coil is energized and turns off when the coil is de-energized.
 - b. NO and NC Form C contacts for indication of a failed trip coil.
 - c. Red LED that illuminates upon failure of the trip coil.
 - d. 200 millisecond delay to allow for auxiliary contacts to transfer.

- e. LEDs:
 - 1) Plug-in replaceable with a life of 100,000 hours.
 - 2) Protected against reverse polarity by a diode.
- f. Control Power: 125 Vdc.

2.7 POWER METER

- A. Provide power meter in each switchboard:
 - 1. Capable of revenue-accuracy metering of electrical parameters including voltage, current, frequency, power factor, kW, kVAr, kWh, and kVArh, and values of kW and kVAr demand.
 - 2. MV90 compatible: Programmable to mimic values metered by El Paso Electric during a 15-minute sliding window.
 - 3. Communications: Modbus TCP/IP Ethernet.
 - 4. Features: Data logging, internal web server, 4 MB of internal memory.
- B. Approved Manufacturer/Product: Electro Industries/GaugeTech, Shark 200, or approved equal.

2.8 INSTRUMENT TRANSFORMERS

- A. Instrument transformers shall conform to IEEE C57.13, with the additional requirements indicated below.
- B. Current transformers:
 - 1. Shall be capable of withstanding thermal and mechanical ratings of the circuit breaker.
 - 2. Molded-rubber or epoxy construction, wound-type or bushing-mounted.
 - 3. Wound-type current transformers:
 - a. Provide separate compartment isolated from the control panel and all other equipment.
 - b. Provide a mounting frame that bolts securely to the switchgear frame.
 - c. Full-wave impulse insulation level: 10 kV.
 - d. Secondary terminal blocks shall have covers with integral shorting bars and secondary wiring shall be run to readily identifiable terminal block points in the control compartment.
 - e. Terminal block points shall also have integral shorting bars for the current transformer leads.
 - 4. Bushing-type current transformers:
 - a. Low-voltage, ring-core, high-accuracy type designed for secure mounting on the primary contact support bushings.

5. Accuracy:
 - a. Protective relaying: Relaying accuracy classification, under the burdens imposed by the specified devices.
 - b. Power Meters: Accuracy Class 0.3 at burden B-0.5.
 - 1) If this metering accuracy is not available, perform an analysis of expected accuracy of metering equipment for loads from 1 percent to 150 percent of actual load rating and submit for approval.
 - 2) Bushing current transformers that will not provide accuracy of plus or minus 0.6 percent at 1 percent load and plus or minus 1.0 percent at full load will be rejected and require installation of wound-type current transformers.
 6. Submit sizing calculations for protection current transformers and metering current transformers. Provide a separate set of current transformers for protective relaying and metering.
- C. Potential Transformers:
1. Molded-rubber or epoxy construction.
 2. Transformers shall have full-wave impulse insulation level of 10 kV.
 3. Primary and secondary circuits of potential transformers shall be fused by means of non-renewable cartridge-type fuses.

2.9 FACTORY ASSEMBLY

- A. Install switchboard in location indicated in accordance with NECA 400.
- B. Anchor in accordance with seismic requirements in Section 26 05 00 Common Work Results for Electrical.
- C. Install supporting members, fastenings, framing, hangers, bracing, brackets, straps, bolts and angles as required to set and rigidly connect the switchboard.
- D. Exercise special care during construction to avoid overloading any part of the structure. Repair or replace items damaged due to overloading.
- E. Field Touch up Painting:
 1. After installations are complete, thoroughly clean surfaces where shop finish is damaged, including bolts, nuts, washers and welds and paint each item with the same paint system as used for shop painting.
 2. Provide matching touch-up painting by approved spray methods, or by brush where approved.

2.10 SOURCE QUALITY CONTROL

- A. Factory Production Tests:
 1. Meters, Instruments and Instrument Transformers:
 - a. Check for accuracy, performance and operation in accordance with IEEE C57.13.
 2. Power Meter: Test accuracy and functionality.

3. In addition to the manufacturer's standard tests, as a minimum perform the following tests at the manufacturer's plant:
 - a. 60 Hz dielectric tests.
 - b. Mechanical operations tests.
 - c. Grounding of instruments.
 - d. Transformer case tests.
 - e. Electrical operation tests.
 - f. Control wiring checks.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install switchboard in built-in-place substation as required in Part 2, above, in the article titled "Factory Assembly."

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification
SECTION 26 24 16
LOW-VOLTAGE PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

- A. Circuit breaker panel boards, including dc distribution panelboard.
- B. Enclosed circuit breakers.

1.2 RELATED SECTIONS

- A. Section 05 05 00 – Common Work Results for Metals
- B. Section 26 05 00 – Common Work Results for Electrical

1.3 REFERENCE STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents, or if standard is adopted by the City of El Paso, the latest revision adopted:
- B. ASTM International (ASTM)
 - 1. ASTM B187, Specification for Copper Bar, Bus Bar, Rod and Shapes
- C. National Electrical Manufacturers Association (NEMA)
 - 1. NEMA PB 1, Panelboards
 - 2. NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum)
- D. National Fire Protection Association (NFPA)
 - 1. NFPA 70, National Electrical Code (with City of El Paso amendments)
- E. Underwriters Laboratories Inc. (UL)
 - 1. UL 67, Panelboards
 - 2. UL 489, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures

1.4 SUBMITTALS

- A. Procedures: Section 01 33 00.
- B. Product Data:
 - 1. Circuit breaker identification.
- C. Shop Drawings:
 - 1. Submit shop drawings and electrical diagrams as follows:
 - a. Panelboards and Load Centers:
 - 1) Show general arrangement, location and identification of the enclosure.
 - 2) Identify each circuit.

- 3) Show location and identification of terminals.
 - 4) Show location of barriers.
 - 5) Furnish wiring diagrams.
 - b. Circuit Breakers: Show circuit for which intended, voltage ratings, insulation level, current rating and interrupting ratings.
- D. Operation and Maintenance Data:
- 1. Submit manufacturer's operating and maintenance instructions on products specified in this Section, including the following:
 - a. Description of the switchboard and its components.
 - b. Manufacturer's operating and maintenance instructions, parts list, illustrations and diagram for components.
 - c. Recommended list of spare parts.
 - d. Wiring diagram.
 - e. Electrical characteristics of each component including relays or solid-state circuitry.
- E. Factory Test Reports: Submit copies of certified reports of factory tests performed in accordance with the applicable referenced standards and specification requirements.

1.5 QUALITY ASSURANCE

- A. Qualifications: Manufacturer that has been regularly engaged in the manufacture of similar equipment and meets UL requirements.
- B. Conform to UL 489, NEMA PB 1, and NFPA 70, as applicable.
- C. Components of the same type, size, rating, functional characteristics and manufacture shall be interchangeable.
- D. Each item shall be UL labeled.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Ship each unit securely wrapped, packaged and labeled for safe handling in shipment and to avoid damage or distortion.
- B. Store in secure and dry storage facility.

PART 2 - PRODUCTS

2.1 PANELBOARDS AND LOAD CENTERS

- A. Comply with NEMA PB 1 and UL 67.

B. Enclosure:

1. NEMA 250 Type 1, fabricated from galvanized steel, surface-mounted unless otherwise indicated, tamperproof, with the following additional requirements:

- a. Gutter size:

<u>Main Bus Rating Amperes</u>	<u>End Gutter Size (Inches)</u>	<u>Side Gutter Size (Inches)</u>
225 and below	6	5
400 and over	8	8

- b. Provide backplate of reinforced steel for mounting of interior components.
- c. Provide device or mechanism for enclosure grounding.
- d. Dead-front type.

C. Cover and Trim:

1. Designed for surface mounting.
2. Door:
 - a. Hinged, fitted with a combination latch and door lock, accommodating a master key.
 - b. Provide one flat key tumbler cylinder-type, nickel-plated door lock conforming to the station master key system, two keys per lock.
3. Circuit Directory: Provide a directory frame with acrylic plastic face mounted on the back of the door.
4. Finish: Powder coat as specified in Section 05 05 00, Common Work Results for Metals.

D. Bus Bars:

1. ASTM B187, 98 percent conductivity copper, with silver-plated contact surface.
2. Provide neutral bus of the same rating as that of phase bus.
3. Provide a full-rated separate grounding bus.

E. Circuit Breakers: Bolt-on type complying with UL 489.

F. Additional Requirements for TPSS Ac Auxiliary Panel:

1. Provide main breaker in panel.
2. If panel is not located on face of switchgear, provide an additional main breaker accessible from the front of switchgear without opening a compartment.

G. Additional Requirements for Dc Panelboards:

1. Designed for two-wire, 125 Vdc ungrounded power distribution service.
2. Circuit breakers: Two-pole, 10,000 A interrupting rating at 250 Vdc minimum.

H. Identification:

1. Provide nameplate or other machine-made permanent identification for each circuit breaker, giving each a unique sequential number.

2.2 ENCLOSED CIRCUIT BREAKERS

- A. Molded case, bolt-on type, quick-make quick-break, with thermal-magnetic type overload trip, interchangeable unit for frame rated 125 A and above, complying with UL 489.
- B. Enclosure: NEMA 250 Type 12, fabricated from galvanized steel, surface-mounted unless otherwise indicated.
- C. Finish: Powder coat as specified in Section 05 05 00, Common Work Results for Metals.

2.3 FACTORY ASSEMBLY

- A. Mounting Height: Locate top 6 feet, 6 inches above finished floor and the bottom not less than 12 inches above finished floor, unless specifically indicated otherwise.
- B. Anchor in accordance with seismic requirements in Section 26 05 00, Common Work Results for Electrical.
- C. Identification:
 - 1. Mount sequential numbers directly on each circuit breaker or on the cover or trim adjacent to each breaker.
 - 2. Provide each panelboard and load center with an accurate, printed circuit directory.
 - a. Identify each circuit, spare breakers, and spaces.
 - b. Numbers on circuit directory must correspond to sequential numbers mounted on each breaker.
 - c. Install in the factory provided directory frame mounted on the back of the door.

2.4 SOURCE QUALITY CONTROL

- A. In addition to the manufacturer's standard tests, as a minimum perform the following tests at the manufacturer's plant:
 - 1. 60 Hz dielectric tests.
 - 2. Mechanical operations tests.
 - 3. Electrical operation tests.

PART 3 - EXECUTION

3.1 FIELD INSTALLATION

- A. Requirements in Article titled "Factory Assembly" apply to field installation.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 26 50 00 LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

- A. Interior substation overhead and emergency lighting.
- B. Exterior substation lighting.
- C. Lighting inside equipment enclosures.

1.2 RELATED SECTIONS

- A. Section 26 05 00 – Common Work Results for Electrical

1.3 REFERENCE STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents, or if standard is adopted by the City of El Paso, the latest revision adopted:
- B. American National Standards Institute (ANSI)
 - 1. ANSI C82.4, Standard for Ballasts for High-Intensity-Discharge and Low-Pressure Sodium (LPS) Lamps (Multiple-Supply Type)
- C. Institute of Electrical and Electronics Engineers (IEEE)
 - 1. IEEE C62.41, Guide on Surge Voltages in AC Power Circuits Rated up to 600V
- D. National Fire Protection Association (NFPA)
 - 1. NFPA 70, National Electrical Code (with City of El Paso amendments)
- E. Underwriters Laboratories Inc. (UL)
 - 1. UL 924, Standard for Safety of Emergency Lighting and Power Equipment
 - 2. UL 1570, Fluorescent Lighting Fixtures
 - 3. UL 1598, Standard for Safety of Luminaires

1.4 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Product Data:
 - 1. Document that proposed luminaires, ballast and lamps fully comply with Contract Documents.
 - 2. Indicate luminaire construction, photometric performance, installation, and maintenance requirements.

3. Include clear and legible product specifications, drawings and illustrations of sufficient detail to describe the following:
 - a. Luminaire housing, hardware, and finishes.
 - b. Light controlling elements.
 - c. Electrical components, including lampholders, ballast, and provision for conduit entry.
 - d. Support details. Indicate weight of luminaire, complete with lamps.
4. Include procedures for installation of the complete lighting unit in its final service location.
- C. Shop Drawings: Lighting layout with proposed luminaires indicated by manufacturer and model number.
- D. Calculations: Show that specified lighting levels are achieved with proposed luminaires.
- E. Operations and Maintenance Data:
 1. Submit manufacturer's operating and maintenance instructions on products specified in this Section, including the following:
 - a. Materials and components clearly indicated in the parts list.
 - b. Relamping methods.
 - c. Special tools required.
 - d. Frequency of inspection, tightening, or other service recommended for preventative maintenance.
 2. Submit immediately after approval of product data.

PART 2 - PRODUCTS

2.1 PERFORMANCE CRITERIA

- A. Each substation shall have interior and exterior lighting to provide the specified minimum light levels.
- B. Minimum Lighting Levels:
 1. Interior: 70 footcandles at 30 inches horizontal above the aisle floor.
 2. Exterior: 2 footcandles, measured at ground level.
 3. Emergency Lighting: Minimum 1 footcandle at 30 inches above the aisle floor.
 4. Minimum lighting levels shall be maintained throughout the TPSS. Average lighting level shall not be used to meet this requirement.

2.2 COMPONENTS

- A. Ballasts:
 1. Mount ballast securely inside luminaire to obtain the necessary heat dissipation.
 2. Ballasts for fluorescent lamps shall match the characteristics of the lamps, and have the following characteristics:
 - a. Operate lamps at a frequency of 20 kHz or higher without visible flicker.

- b. Listed Class P.
- c. Total Harmonic Distortion: Less than 10 percent at 277 V.
- d. Current crest factor: Less than 1.5.
- e. Power factor: 0.98 minimum.
- f. Audible noise rating: Class A or better.
- g. Contain no Polychlorinated Biphenyls (PCBs).
- h. Transient protection: IEEE C62.41, Category A.
- i. Inherent thermal protection.
- j. Provide constant light output with input voltage fluctuation of plus or minus 5 percent.
- k. Provide instant-start for parallel wiring connection of lamps. Allow remaining lamps to maintain full output, in the event of lamp failure on multiple lamp luminaire.
- l. Provide reliable lamp starting at 50 degrees F for interior luminaires and 0 degrees F for exterior luminaires.

3. HID Ballasts: ANSI C82.4, fused.

B. Lamps:

- 1. Provide lamps used in the illumination system of standard manufacture, readily available, and of the highest efficiency and life consistent with other requirements of the illumination system.
- 2. Ensure all lamps of each type are provided by a single manufacturer.

3. Fluorescent Lamps:

- a. Energy-efficient T8, rapid-start fluorescent lamp.
- b. Life: Ensure lamps have a rated minimum average life of 20,000 hours.
- c. Color Temperature: Minimum 3500 degrees K Correlated Color Temperature (CCT).
- d. Color Rendering Index (CRI): Minimum 78.
- e. Environmental: Use lamps for T8 fluorescent lighting that have reduced mercury contents that meet U.S. Environmental Protection Agency (EPA) Toxic Characteristic Leaching Procedure (TCLP) test for nonhazardous fluorescent light waste.

4. Metal Halide Lamps:

- a. Suitable for all operating positions. Ensure Photometric characteristics provide maximum luminous output while operating in the horizontal position.
- b. Color temperature: 3700 degrees K.
- c. Color Rendering Index (CRI): 70.

C. Reflector Material: Prefinished, copper-free aluminum alloy, minimum thickness 0.032 inch, Architectural Type 1 with Class M1 anodic coating providing 83 percent reflectivity.

2.3 LUMINAIRES

A. Interior of Substation Enclosure

1. Ceiling mounted, industrial fluorescent luminaire with clear, prismatic diffuser complying with UL 1570.
2. Acrylic lens: Manufactured from virgin-acrylic extrusion or injection molding pellets.

B. Exterior of Substation Enclosure

1. Wall-mounted, vandal-resistant, LED luminaire, full cut-off type.
2. UL listed for 40 degrees C. maximum ambient and wet locations with IP66 ingress rating. Luminaire shall comply with IES LM-79 and LM-80 and be DLC (Design Lights Consortium) qualified.
3. Housing: Die-cast aluminum, with a hinged door secured by captive stainless steel, tamper-resistant screw. Housing shall incorporate cooling fins specifically design for cooling LED light source and driver. Approximate dimensions of complete luminaire: 6"Wx7"Hx4"D including back-box. Provide with wire guard.
4. Finish: Epoxy or polyester powder-coat paint, white.
5. Optical: Sealed LED compartment with anodized, mirror-finish, forward-throw reflector, high-output bright-white (5000K CCT) LED, impact resistant tempered glass lens and silicone sealing gaskets. Luminaire shall deliver at least 1400 lumens, be rated full-cutoff with BUG rating B1-U0-G0 or better, and be suitable for wall-mounting 8 feet or greater above surrounding surface.
6. Electrical: Integrated electronic LED driver with integral surge protection shall be mounted to housing for effective cooling. Provide luminaires with integral photocontrol or a single NEMA-style, aimable photocontrol wired in luminaire circuit.
7. Acceptable Product: Lumark XTOR2A-WT-WG or approved equal.

C. Emergency Lighting:

1. Self-contained units containing lamps, battery, battery charger, controls, test switch, and status indicator.
2. Lighting Heads: High-output 4.5 W LED MR16 lighting heads; minimum two lamps per unit.
3. Battery:
 - a. Nickel-cadmium, 12 V, rechargeable, sealed, maintenance-free.
 - b. Capacity: Shall supply rated lamp load for 1-1/2 hours, minimum.
 - c. Life expectancy: 10 years.
4. Battery charger:
 - a. Solid-state, current-limited, temperature-compensated, short-circuit proof, and reverse-polarity protected with plus-or-minus 1 percent regulation.
 - b. Charger shall automatically maintain battery in fully-charged float condition and be capable of providing full recharge in 12 hours.
5. Unit controls shall energize the lamps automatically upon failure of the ac power supply and disconnect load before battery low-voltage limit is reached.

6. Housing: UV-stabilized, high impact, clear 0.120-inch polycarbonate or 18-gage steel, with a baked enamel finish.
7. Listing: UL listed for emergency lighting.
8. Luminaires shall be complete with lamps in place.
9. Acceptable Product: Kenall METEL-series LED or approved equal.

2.4 LIGHTING INSIDE EQUIPMENT ENCLOSURES

A. Luminaire:

1. Ceiling and side mounted, LED strip luminaire with clear, prismatic diffuser complying with UL 1570.
2. Minimum illuminance: 30 fc at 1.5 feet.
3. Color Temperature: 6000 K
4. Minimum Length: 6 inches less than cubicle width.
5. MTBF: 40,000 Hours
6. Acceptable Product: LBFA Lux Bar LED light bar, or approved equal.

2.5 FACTORY ASSEMBLY

A. Luminaires shall be supplied from the substation ac panelboard.

B. Comply with NFPA 70.

C. Interior Luminaires:

1. Locate to illuminate the vertical surfaces of equipment.
 - a. Coordinate to avoid interference with overhead raceways or other major wiring or blocking of the light.
 - b. Luminaires shall not be mounted directly above equipment.
2. Switches:
 - a. Provide 3-way switches complying with requirements for switches in Section 26 05 00, Common Work Results for Electrical
 - b. Mount inside by each entry door.

D. Exterior luminaires: Locate as indicated on Contract Drawings, unless otherwise approved by Engineer.

E. Emergency lighting:

1. Supply from substation ac panelboard.
2. Wire unswitched.

F. Lighting inside equipment enclosures:

1. Locate on ceiling and sides to light the interior of each equipment enclosure.
2. Switch locally with external switch complying with requirements for switches in Section 26 05 00, Common Work Results for Electrical.
3. Provide lighting for control and power cubicles within the ac switchgear, transformer, rectifier, and dc switchgear cubicles.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Requirements of Article titled "Factory Assembly" apply to field installation.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification
SECTION 34 11 05
SYSTEMS RAIL BONDING

PART 1 - GENERAL

1.1 SUMMARY

- A. Power bonding, cross bonding, and rail connections for traction electrification system.

1.2 REFERENCE STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents:
- B. International Organization for Standardization (ISO)
 - 1. ISO 9001, Quality Management Systems – Requirements
- C. Underwriter's Laboratories (UL)
 - 1. UL 467, Grounding and Bonding Equipment

1.3 RELATED SECTIONS

- A. SECTION 34 11 23.50 – Elastomeric Encapsulation

1.4 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Product Data: Description and catalog cut of proposed components and hardware items to be provided including the following:
 - 1. Proposed stub-end bonds for each size cable to be used identifying part number, wire size, stranding, and terminations.
 - 2. Weld material.
 - 3. Exothermic weld molds for each type of application.
- C. Testing Documents:
 - 1. Submit rail bonding testing documents under this section.

1.5 QUALITY ASSURANCE

- A. Engineer will inspect bonds for conformance to these Specifications.
- B. Remove bonds rejected by Engineer that have been deemed poor quality by Engineer and replace with a new bond at Contractor's expense.
- C. Qualifications: Manufacturer of exothermic welding system shall be ISO 9001 certified.

PART 2 - PRODUCTS

2.1 EXOTHERMIC WELDING SYSTEM

- A. Welding mixture: Copper based exothermic mixture designed for permanent grounding or bonding connections, approved for outdoor use, and meeting UL 467.

- B. Molds: Specifically designed for exothermic welding of cable to web of rail.
- C. Stub-End Bond: Pre-formed, extra-flexible stranded copper cable, designed to assist exothermic weld process to a rail web, sized for each cable type.
- D. Approved Manufacturers/Products:
 - 1. Erico, Cadweld;
 - 2. Continental Industries, Thermoweld; or approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Connect negative returns to rail and provide crossbonding at locations shown on Contract Drawings.
- B. Install rail connections and bonding in accordance with approved procedures, installation drawings, and in accordance with manufacturer's recommendations.
- C. Maintain running rail electrical isolation from ground.

3.2 RAIL CONNECTIONS

- A. Heat rail to remove trapped moisture.
- B. Clean surfaces of rails with a vitrified grinding wheel before welding.
- C. Clean rails with "Inhibisol" or other approved nontoxic solvent to remove traces of dirt and debris from grinding operations.
- D. Exothermically weld stub-end bond to rail.
- E. Stagger at intervals of not less than 8 inches on centerline.
- F. Center bonds: Weld to web of rail within plus or minus 1/4 inch of neutral axis.
- G. Rail-weld inspection and test:
 - 1. Visually inspect each weld in accordance with manufacturer's manual on installation.
 - 2. Test each weld to rail by striking sharply with a 2-pound hammer.
 - 3. Test bond resistance: Maximum of $(\text{Bond Length (ft)} \times 0.000011 \text{ (ohms/ft)}) + 0.00016 \text{ (ohms)}$.
- H. Remove defective bonds.
- I. Repeat or broken welds due to misfires, poor fusion, or other causes shall be relocated a minimum of 4 inches on centerline from their original weld locations.

3.3 EXOTHERMIC SPLICE

- A. Exothermically weld rail connection stub-end bond to power cable.
- B. Do not connect splice until rail connection has passed visual inspection, hammer test, and resistance test.
- C. Provide sufficient slack to accommodate rail movement due to expansion and contraction.

3.4 ELASTOMERIC GROUT

- A. Product: Refer to SECTION 34 11 23.50 – Elastomeric Encapsulation
- B. Provide elastomeric grout in track blockouts per contract drawings.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 34 21 05

COMMON WORK RESULTS FOR TRACTION ELECTRIFICATION SYSTEM (TES)

PART 1 - GENERAL

1.1 SUMMARY

- A. Design, building, delivering, picking, and setting of prepackaged traction power substations (TPSS) on slab, and installation of field erected traction power substations in the maintenance shop facility (MSF).
- B. Temporary power for TPSS HVAC.
- C. Coordinating utilities to substations.
- D. Miscellaneous materials, equipment, and components including but not limited to fasteners and hardware, insulating materials, relays, contacts, coils, switches, indicators, smoke detector, blue light, Knox box, mobile work station, fire extinguisher, and dc breaker test station.
- E. Requirements for interlocking in the Maintenance Shop Facility (MSF).
- F. Requirements of this Section apply to all 34 21 xx sections.

1.2 RELATED SECTIONS

- A. Section 05 05 00 – Common Work Results for Metals
- B. Section 09 67 25 – Dielectric Epoxy Flooring
- C. Section 26 05 00 – Common Work Results for Electrical
- D. Section 26 05 10 – Common Work Results for Systems Conductors and Cable
- E. Section 26 05 43 – Underground Ducts and Raceways for Electrical Systems
- F. Section 34 21 16 – TPSS Enclosures
- G. Section 34 21 31 – Substation Automation System (SAS)
- H. Section 34 21 80 – TES Spare Parts and Special Tools

1.3 DEFINITIONS

- A. Intelligent Electronic Device (IED): Refers to any digital or numerical-based protection, metering, control, or monitoring device that has processing, recording and reporting capabilities and a local human machine interface (HMI).

1.4 REFERENCE STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents, or if standard is adopted by the City of El Paso, the latest revision adopted:
- B. American National Standards Institute (ANSI)
 - 1. ANSI Z535.2, Environmental Facility and Safety Signs
- C. Code of Federal Regulations (CFR)
 - 1. CFR Title 29, Part 1926, Subpart G, Signs, Signals, and Barricades

- 2. CFR Title 47, Part 15, Radio Frequency Devices
- D. Institute of Electrical and Electronics Engineers (IEEE)
 - 1. IEEE C37.90, Standard for Relays and Relay Systems Associated with Electric Power Apparatus
 - 2. IEEE C37.90.2, Standard for Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers
- E. National Electrical Contractors Association (NECA)
 - 1. NECA 1, Standard Practice of Good Workmanship in Electrical Construction
- F. National Electrical Manufacturers Association (NEMA)
 - 1. NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum)
- G. National Fire Protection Association (NFPA)
 - 1. NFPA 70, National Electrical Code (NEC) (with City of El Paso amendments)
- H. State of Texas
 - 1. Texas Administrative Code (TAC), Title 16, Part 4, Texas Department of Licensing and Regulation, Chapter 70, Industrialized Housing and Buildings

1.5 COORDINATION

- A. Coordinate delivery of prefabricated substation with Engineer.
 - 1. Before picking substation off truck, obtain approval to partially or completely restrict a city street, sidewalk, or alley with the City of El Paso.
- B. Electric Utility, El Paso Electric (EPE):
 - 1. Coordinate with EPE:
 - a. Location of EPE service points to feed each TPSS.
 - b. Type of CT enclosure, meter socket, and utility main disconnect switch.
 - c. Installation of CT enclosure, meter socket, and utility main disconnect switch.
 - d. Installation by EPE of current transformers (CTs) into CT cabinet on the substation.
 - e. Installation by EPE of metering wiring to meter base on the substation.
 - f. Connection of permanent power to substations with El Paso Electric.
 - 2. Current transformers and metering wiring are furnished by EPE.
 - 3. Owner will pay utility bill for permanent power at each substation from the time of connection of permanent power.

1.6 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Product Data: Submit manufacturer's product data for products specified in this Section if not submitted under another Section:
 - 1. Utility current transformer (CT) cabinet, meter socket, and main disconnect switch.

2. Relays.
 3. Switches and indicators.
 4. Intrusion detection switches.
 5. Terminal blocks.
 6. Smoke detector.
 7. Exterior blue light, including luminaire, lens, LED light, and flasher.
 8. Knox box.
 9. Mobile work station.
 10. Fire extinguisher.
 11. Dc breaker test station.
 12. ETS buttons and enclosures.
 13. Fasteners.
 14. Hardware.
 15. Cable ties.
 16. Electrical insulating laminate.
 17. Software.
 18. Identification products.
 19. Sealing strip.
- C. Submit for information only:
1. Substation setting plan, including diagram showing position of truck and crane and description of steps involved.
 2. Substation anchoring design sealed by a structural engineer registered in the State of Texas.
- D. Spare Parts:
1. Submit a list of spare parts to be provided under this Section.
 2. Submit at the same time as product data.
 3. Provide part numbers for each part, including a detailed break-down of each spare part assembly and set, as defined in Section 34 21 80, TES Spare Parts and Special Tools.
- E. Shop Drawings:
1. Provide the drawing types listed below for substations.
 - a. Comply with Owner's drafting standards.
 - b. Drawing Scale:
 - 1) Use only standard architectural or engineering scale. Non-standard scales, such as 15 inches equals 1 foot, will not be accepted.

- 2) Drawings must be properly converted to pdf format such that scalability is maintained.
2. One-line Diagrams: Provide for each substation.
3. Three-line Diagrams: Provide for each substation.
4. Schematic Diagrams:
 - a. Format by subsystem, using identical device symbols and wire designators for each subsystem.
 - b. Clearly delineate interfaces, from page to page and subsystem to subsystem.
 - c. These drawings shall include at least the following information:
 - 1) Wire connections, terminations and identification.
 - 2) Nominal voltages, equipment and equipment ratings, currents, frequencies, significant resistance values, and the rating of all loads.
 - 3) All low voltage dc control circuits.
 - 4) Schematic location (page number, for example) of the energization portion of each device (such as the coil in a relay) noted adjacent to the operating portions (such as relay interlocks) of the device.
5. Wiring diagrams:
 - a. Provide a set of wiring diagrams for each substation.
 - b. Show all wiring, raceways, conduits, and connections.
 - c. Provide equipment connection, intra-cubicle, and inter-cubicle wiring diagrams.
 - d. Connection diagrams: Show the internal wiring and terminal block arrangement within each piece of equipment and identify each outgoing power and control connection and wire.
 - e. Interconnection diagrams: Show wiring from the equipment terminal blocks, to external equipment connections, terminal blocks, and devices.
 - f. Show nominal voltages, equipment and equipment ratings, currents, frequencies, significant resistance values, and the rating of all loads.
 - g. Label devices identical to the actual device and show their locations on panels.
 - h. Each terminal block and device shall have its own unique numbers and letters for identification.
 - i. As a minimum, provide the following information for each wire segment:
 - 1) Wire code (schematic designation).
 - 2) Origin (FROM device and terminal).
 - 3) Destination (TO device and terminal).
 - 4) Wire size.
6. Substation Equipment and Raceway Drawings: Show actual equipment to be provided and raceways, with all drawn to scale.

7. Panel schedules: Submit for each panel to be provided.
8. Equipment arrangement drawings:
 - a. Show actual equipment to be provided and details of installation, drawn to scale, using layout provided in Contract Drawings.
 - b. Alternate substation equipment layouts may be proposed by Contractor, subject to Engineer's approval.
 - c. Provide the following drawings as a minimum:
 - 1) Certified substation footprint with locations of openings for incoming and outgoing feeders within 45 days of NTP.
 - 2) Substation plans and elevations showing the equipment layout, including equipment numbers, locations, and dimensions.
 - 3) Equipment front elevations and wall elevations showing the location of each piece of equipment and dimensions.
 - 4) Installation and mounting details for all equipment, including installation of the transformer enclosure partitions, method of anchorage for each piece of equipment, and method for providing electrical isolation for the dc switchgear.
 - 5) Raceway layout plans showing cable trays, conduits, including numbers, locations, and dimensions.

F. Substation ANSI Device Table:

1. Provide a set of device tables for substation ANSI devices in a single section at the rear of the schematic book.
2. Arrange the table in a logical fashion by system device type.
3. Provide data for all system and subsystem components including, but not limited to the following:
 - a. Electrical control and power components (groups, panels, pc cards, contactors, relays, circuit breakers, capacitors, inductors, resistors, specialized modules, rectifiers, diodes, fuses and other components, as appropriate).
 - b. Electrical equipment (rectifiers, transformers, switchgear, substation alarm panel, interface terminal board, and the like).
4. Include the following data:
 - a. Equipment and associated number where a device is located.
 - b. Elementary schematic drawing number where the device appears.
 - c. A brief description of the device.
 - d. Manufacturer's model or style number.
 - e. Manufacturer's name and type number of the device.
 - f. Device rating.
 - g. Number, rating, and types of contacts on device, if applicable.
 - h. Remarks on any other relevant features of the device.

G. Bill of Materials (BOM): Provide the following information:

1. Contract number.
2. Supplier number.
3. Provision for Owner's stores number.
4. Other data required for procurement of materials used in the construction of all parts of the electrification system.
5. Cross-reference between related drawings and the BOMs.
6. Generic description or specification.
7. Brand name, where applicable.
8. Manufacturer's part number.
9. Original manufacturer or supplier, including address, telephone number, e-mail address, FAX number, and contact person.
10. Notation on parts that are custom manufactured only upon request.

H. Operations and Maintenance Materials:

1. Submit manufacturer's operating and maintenance instructions on products specified in this Section.
2. Submit immediately after approval of product data.
3. Include manufacturer's operating and maintenance instructions, parts list, illustrations and diagram for components, and recommended maintenance materials and spare parts list.

I. Samples: Submit a sample of each type of identification product.

J. Substation History Books:

1. The substation "history book" shall contain a complete record for each substation, shall be kept up to date throughout the manufacturing process, and may be inspected by the Engineer at any time.
2. Provide a history book for each substation, with the following information at a minimum:
 - a. Copy of approved plan review, if plan review is required by state law or city ordinance.
 - b. Factory production test reports.
 - c. Description and completion dates of substation modifications, and a list of modifications pending with expected completion dates.
 - d. A record of abnormalities that occur during the manufacture of the substation or its subsystems, including their authorized repair procedures.
 - e. List of substation defects that were identified by the Contractor's QA or the Engineer during assembly, commissioning, and testing, and the disposition of each as verified by inspection.
 - f. List of serial-numbered apparatus.
 - g. Shipping documents.
 - h. Field acceptance test reports.

- i. Integrated testing reports.
 - j. Final relay settings.
 - k. Copy of final rail voltage monitoring and grounding system settings.
 - l. Copy of permit signed off by the issuing department.
 - m. Open items status list.
3. Changes in recorded data that are made during performance of the Contract shall be clearly identified and justified to the satisfaction of the Engineer.

1.7 SPARE PARTS

- A. Provide spare parts in accordance with Section 34 21 80, TES Spare Parts and Special Tools.
- B. List below applies to items in this Specification Section.
 1. Blue light: Provide 2 spare.

1.8 QUALITY ASSURANCE

- A. Regulatory Requirements:
 1. Comply with current federal, state, and local requirements.
- B. Qualifications:
 1. Electrical work at TPSS manufacturer's plant shall be performed by electrical workers skilled in the installation of electrical equipment and knowledgeable in the requirements of NFPA 70 and NECA 1, as certified by manufacturer's Quality Program Plan.
 2. Welding shall be done by welders qualified as stated in Section 05 05 00, Common Work Results for Metals.
- C. General Performance Requirements:
 1. Provide electrification equipment proven in similar railroad, rail transit, or heavy industrial service and make use of this experience to prepare a suitable and proven design for this application.
 2. Each component, subassembly and assembly provided in this Contract shall be of a proven design with a history of at least 5 years successful operation at the time of Contract award in similar railroad or rail transit service.
 3. Systems Integration: Integrate TES elements such that specified requirements are achieved without conflict or error within or between specified elements.
 4. Traction Power Substation Expected Service Life: 50 years in continuous service, 24 hours a day, 365 days a year.
 5. Use off-the-shelf service-proven equipment and hardware approved by the Engineer to achieve this useful life.
 6. Provide replacement spare parts that are functionally and physically interchangeable for each product class.
- D. Listed and Labeled Equipment and Material:
 1. Provide wherever standards for these products have been established.
 2. Materials that are not listed or labeled require approval by Engineer before use.

3. Products that have not been tested or certified for the use intended shall not be used when equivalent listed or labeled materials are available.
4. The label or listing will be acceptable as sufficient evidence that the materials and equipment do conform to the specified standards.
5. Electrical equipment and material not listed or labeled shall be furnished with a Field Evaluation label provided by an approved Testing Laboratory, and certifying that the equipment conforms to the requirements of UL and ANSI.
 - a. This product evaluation may be performed in the factory or on-site as approved by Engineer.
 - b. A request for permission to perform a Field Evaluation in the factory or onsite shall be submitted to Engineer for approval.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Before shipment of TPSS, verify that Texas Department of Licensing and Regulation (TDLR) insignia has been affixed to building indicating that it meets Texas Administrative Code (TAC) requirements. See Section 34 21 16, TPSS Enclosures, for additional information.

1.10 WARRANTY

- A. Provide an extended warranty for unproven equipment.
- B. Unproven equipment means equipment that meets any one of the criteria described below:
 1. Equipment that is not service proven in the rail transit industry in the United States. To be service proven equipment shall have been in use for a minimum of five years.
 2. Equipment or assemblies that have not been used before by this manufacturer in the rail transit industry in the United States.
 3. Equipment or assemblies that use software developed from the ground up for this project.

PART 2 - PRODUCTS

2.1 TRACTION POWER SUBSTATION DESCRIPTION AND DESIGN CRITERIA

- A. Traction Power Substation General Parameters:
 1. Provide complete factory assembled traction power substation in weatherproof enclosure.
 2. Substation rating: 350 KW, light traction service.
 3. Substations will be unattended.
 4. Dc System Voltage:
 - a. 600/750 Vdc at rated load.
 - b. Maximum Voltage with Regeneration: 900 Vdc.
 - c. Regulation: 4.5 percent between 1 percent and 200 percent load.
- B. MSF Traction Power Substation General Parameters
 1. Provide field assembled traction power substation in MSF
 2. Substation rating: 150kW, light traction service.

3. Substations will be unattended.
4. Dc System Voltage:
 - a. 600/750 Vdc at rated load.
 - b. Maximum Voltage with Regeneration: 900 Vdc
 - c. Regulation: 4.5 percent between 1 percent and 200 percent load.
- C. Environmental Requirements: Provide substation suitable for operation without impairments at its standard ratings throughout the range of worst values listed below:
 1. Ambient Outdoor Temperature: 15 degrees F to 115 degrees F.
 2. Maximum Ambient Outdoor Humidity: 100 percent.
 3. Design Wind Speed: 75 mph.
 4. Seismic: Comply with Section 26 05 00, Common Work Results for Electrical.
 5. Altitude: 4,000 feet above sea level.
- D. Utility Data: Power to the traction power substations will be supplied from El Paso Electric (EPE) at 480 V. Other required utility data may be obtained from EPE.

2.2 GENERAL TRACTION POWER SUBSTATION REQUIREMENTS

- A. The proposed TPSS equipment must fit within the space as shown in Contract Drawings.
- B. Substations shall be identical to each other in every respect, including electrical equipment, traction power equipment, appurtenances, raceways, wiring, terminal blocks, and wiring connections. Equipment shall be fully interchangeable without modification.
- C. Material and Equipment Requirements:
 1. Material shall be new and in first class condition, suitable for the use intended and of the manufacturer's latest standard design
 2. Discontinued materials or products shall not be used.
 3. Materials and equipment shall be standard products of manufacturers regularly engaged in the production of such material and equipment.
 4. Where two or more units of the same class of material or equipment are required, provide products of a single manufacturer.
 5. Similar component parts of different larger assemblies are not required to be the products of the same manufacturer.
 6. Each type of material and equipment shall be of the same manufacture and quality throughout the Work.
- D. Conveniently locate devices requiring regular calibration, resetting or operation within easy reach of personnel.
- E. Design substation to comply with applicable noise regulations with substation equipment operating at rated full load capacity, and sound measured from outside substation on all sides.
- F. Provide breaker or switch auxiliary contacts where position indications from circuit breakers or disconnect switches are required. Auxiliary relays are not acceptable to monitor position indication of circuit breakers or disconnect switches.

2.3 TPSS COMPONENTS AND PRODUCTS

A. Utility Metering:

1. Meter base : Provide EUSERC compliant metering equipment complying with requirements of EPE described in EPE's "Electric Service Requirements" book, also referred to as "The Blue Book."
2. Conduit to meter base: Comply with EPE requirements in the Blue Book.
3. CT cabinet: Galvanized steel, complying with requirements of EPE.
4. Service disconnect: Provide load break rated disconnect complying with requirements of EPE described in EPE's "Electric Service Requirements" book, also referred to as "The Blue Book."

B. Relays:

1. Drop-out Voltage: 80 V.
2. Contacts:
 - a. Current rating: Based on continuous, inrush, or interrupting requirements for the duty category as defined by IEC 60512-15-8 Ed. 1.0 b:1995, whichever is most stringent, and then derated by at least a factor of four.
 - b. Voltage rating: Contacts shall be rated for a minimum of twice the applied voltage.
 - c. Select materials for the actual loads and not solely on the device rating. Silver bifurcated contacts and gold alloy bifurcated cross-bar contacts are preferred on low level and dry circuits, respectively.
3. Coils:
 - a. Coils of all devices shall be suppressed, except where performance may be affected.
 - b. Unsuppressed coils are permitted only with written approval of the Engineer.
4. Service Life: Relays shall have a guaranteed mechanical service life of at least 50 years.
5. Protective relays: IEEE C37.90, utility grade, immune from inadvertent operation due to ambient EMI, including radio frequency signals.
6. Auxiliary and control relays:
 - a. Heavy duty, UL listed.
 - b. Mechanical durability: Minimum 50,000 cycles.
 - c. Electrical durability: Minimum 100,000 cycles for resistive load.

C. Switches and Indicators:

1. Position switches (Device 33): Roller plunger type switch, rated heavy or medium duty, brass or steel plunger, metallic enclosure, rated for 20,000 operations, minimum.
2. Indicating Lights:
 - a. Long-life, high-brightness using LED arrays and integral current limiting resistors.
 - b. Indicators shall be selected to permit maximum visibility in direct sunlight from all viewing angles.

D. Intrusion Detection:

1. Door switches: Magnetic, rated heavy or medium duty, metallic case, screw mounted.

E. Terminal blocks: Heavy duty, suitable for use with ring terminals, with insulated, removable covers.

F. Smoke detectors:

1. Ionization photoelectric type.
2. Plug-in unit with mounting plate hard wired.
3. Integrally self-monitoring, self-diagnostic, with visual trouble indication.
4. Designed to reduce false alarms from dust, insects, radio frequency interference (RFI), and external light.

G. Exterior Blue Light:

1. LED blue color light, 360 degrees illumination, suitable for wet locations, suitable for pipe-mounting on OCS pole.
2. Exterior blue lights shall be mounted on the exterior of the substation enclosure. Blue light shall be installed on an OCS pole as shown on the Contract Drawings.
3. Light shall incorporate a fail-safe circuit with an annunciator indicating failure of the LED, power supply, or fuse.
4. Approved Manufacturer/Product: Federal Signal LED Pulsator 212650-3, or approved equal.

H. Knox box with lock: 6 inches by 6 inches by 4 inches. Obtain keying requirements from El Paso Fire Department.

I. Mobile Workstation:

1. Construction:
 - a. Heavy-duty structural foam.
 - b. Capacity: 750 pounds.
2. Features:
 - a. Wheels: Four 5-inch casters.
 - b. Drawers: Four, with ball bearing door slides.
 - c. Cabinet with adjustable shelf.
 - d. Built-in drawer lock.
3. Nominal Dimensions:
 - a. Width: 49 inches.
 - b. Depth: 26 inches.
 - c. Height: Nominal 38 inches.
4. Approved Manufacturer/Product: Rubbermaid TradeMaster, Model 4533-88 or approved equal.

- J. Fire extinguisher: Portable, appropriate for equipment provided, 20 pound, CO₂.
- K. Dc breaker test station:
 - 1. Capable of tripping dc breaker.
 - 2. Umbilical cord:
 - a. For connecting to breaker.
 - b. Provide strain relief where cord connects to cabinet.
 - c. Provide means to conveniently stow umbilical cord when not in use.
- L. Emergency Trip Stations:
 - 1. ETS Buttons: Heavy duty, industrial grade, latching with twist release, pushbutton operator and contact block, rated for the load, minimum 2-inch diameter mushroom head, red.
 - 2. Protective cover: Provide cover or shield to prevent inadvertent activation. Engineer will determine whether proposed protective cover is suitable for the intended purpose.
 - 3. Enclosure:
 - a. Substation Interior: NEMA 250, Type 1.
 - b. Substation Exterior: NEMA 250 Type 4X, stainless steel, gasketed, hinged, lockable. Provide padlock keyed as directed by Engineer.
 - c. Maintenance Shop Facility: NEMA 250 Type 4.
- M. Sealing Strip: Water and humidity resistant moisture barrier.
 - 1. Neoprene rubber pad, durometer hardness Shore A 60, tensile strength 900 psi, elongation 300 percent, 1/4 inch by 6 inches.
 - 2. Acceptable Manufacturer/Product: Biltrite Commercial Neoprene, Style 10.

2.4 MATERIALS

- A. Fasteners, Hardware:
 - 1. Fasteners: Stainless steel. Double-sided tape shall not be used for attachment of channel or wire supports.
 - 2. Hardware:
 - a. Corrosion resistant.
 - b. Suitable for the use and environment intended by the manufacturer.
 - c. Unplated steel shall not be used.
- B. Cable ties (tie wraps): Comply with requirements of Section 26 05 10, Common Work Results for Systems Conductors and Cable.

2.5 PROTECTION OF MATERIAL AND EQUIPMENT FROM ENVIRONMENT

- A. Material and equipment shall be designed to ensure satisfactory operation and life in the environmental conditions that exist where the material or equipment is installed.
- B. Material and equipment shall be suitable for its intended environment.

1. Wet locations: NEMA 250 Type 4X corrosion resistant stainless steel enclosures.
 2. Indoor damp locations: NEMA 250 Type 12 enclosures fabricated from painted-galvanized or stainless steel.
 3. Wet or damp locations: Corrosion resistant fittings or supports, hot-dip galvanized or as otherwise specified.
 4. Exposed dry locations: Corrosion resistant painted finishes may be used for equipment and enclosures as approved by Engineer.
- C. Ferrous Metal:
1. Above Grade: Hot-dip galvanized, galvanized, or powder coated. Refer to Galvanizing or Shop Applied Coatings in Section 05 05 00, Common Work Results for Metals.
- D. Galvanizing:
1. Wherever "galvanized" or "hot-dip galvanized" is called out in these Specifications, the material shall be coated in accordance with galvanizing requirements in Section 05 05 00, Common Work Results for Metals.

2.6 INSULATING MATERIALS

- A. Wherever "electrical insulating laminates", "laminates" or "glastic barrier" are called out in the Contract Documents, use the following:
1. Acceptable Manufacturer/Product: Roehling Glastic Composites, Glastic 1494, or approved equal.
 2. Thickness: 1/4 inch.
- B. Electrically Insulated Floor Covering: Specified in Section 09 67 25, Dielectric Epoxy Flooring.
- C. Sheet rubber: Minimum thickness 0.8 mm.
- D. Prohibited insulating materials.
1. Electrical insulating paper, also called "fish paper".
 2. Electrical tape of any type.

2.7 SOFTWARE

- A. Provide interface and configuration software for uploading settings to and downloading event history from intelligent electronic device (IED).
- B. Provide software that will work with each type of IED provided under a Division 34 Specification Section.
- C. Software shall work on a standard laptop with Microsoft Windows XP and 7 operating systems.

2.8 RADIO FREQUENCY INTERFERENCE

- A. Design TPSS equipment, protective relays meters, instruments and devices to minimize the radio frequency generated in accordance with CFR Title 47 Part 15.
- B. Design TPSS equipment, protective relays, meters, instruments and devices such that they are immune to mis-operations caused by ambient radio frequency signals, in accordance with IEEE C37.90.2.

2.9 WARNING SIGNS

- A. Material:
 - 1. Exterior locations: Baked porcelain enameled steel, with the porcelain enamel forming a complete ceramic envelope around the steel plate.
 - 2. Interior locations: 3.5 mil adhesive backed vinyl film with digital or screen-printed images.
- B. Color: Compliant with CFR Title 29 Part 1926, Subpart G and ANSI Z535.2.
- C. Text:
 - 1. TPSS Entry doors: "DANGER; HIGH VOLTAGE" and "DO NOT ENTER."
 - 2. TPSS Exterior equipment access doors: "DANGER: LIVE PARTS" and "DANGER HIGH VOLTAGE."
 - 3. TPSS Cubicles with 750 V or above: "DANGER: LIVE PARTS" and "DANGER HIGH VOLTAGE."
- D. Location:
 - 1. TPSS Entry doors: Exterior of door.
 - 2. TPSS Exterior equipment access doors: Exterior of door and front of removable panel inside exterior door, if any.
 - 3. TPSS Cubicles with 750 V or above: Front, rear, and side access doors.

2.10 IDENTIFICATION

- A. Equipment Identification
 - 1. Provide a number for each major piece of equipment such as switchgear sections, circuit breakers, and devices.
 - a. Prefix: Traction power substation number, as indicated on Contract Drawings.
 - b. Suffix: Indicates the type of equipment or device.
 - 2. Use the Owner's numbering scheme on submitted Contractor drawings and submittals.
 - 3. Place the Owner's part number on as-built drawings.
 - 4. Engineer will furnish numbering standard.
- B. Wire and Cable:
 - 1. Develop an identification scheme for wires and cables for use on Contractor drawings.
 - 2. For wire and cable tag requirements, see Section 26 05 00, Common Work Results for Electrical.
- C. Nameplates: For requirements, see Section 26 05 00, Common Work Results for Electrical.
- D. Permanently identify equipment with engraved metal labels containing the following:
 - 1. Supplier's name.
 - 2. Part number.
 - 3. Revision level.

E. Serial Numbers:

1. Assign discrete serial numbers in sequential, numerical order for the total quantity of each component, including spares.
2. Serial numbers are subject to the Engineer's approval.
3. Duplicate serial numbers shall not be used within the type or model.
4. Present to the Engineer as each portion of the installation is completed or when spare components are received.
5. Track serial number transfers and prepare a list of all serial-numbered apparatus installed in each TPSS for inclusion in the TPSS history book.
6. At a minimum, the following equipment shall have serial numbers applied:
 - a. Ac main breaker.
 - b. Rectifier transformer.
 - c. Rectifier assemblies.
 - d. Interphase transformers.
 - e. Dc feeder breakers.
 - f. Auxiliary power transformer.
 - g. TPSS alarm panel HMI.
 - h. Motors within equipment.
 - i. Electronic cards.
 - j. Enclosures.
 - k. Manually-operated disconnect switches.

2.11 FACTORY ASSEMBLY

A. General:

1. Torque bolted connections with a calibrated torque wrench in accordance with manufacturer's recommendations or Section 26 05 00, Common Work Results for Electrical, and apply torque marks.

B. Utility metering: Install in compliance with EPE requirements.

C. Relays:

1. Wire Terminations: Terminate a maximum of two wires on relay or contactor terminals.
2. Orientation: Mount and orient relays and contactors as recommended by the supplier or manufacturer.

D. Switches and Indicators:

1. Position switches (Device 33):
 - a. Provide at the following door locations to trip and lock out the ac main breaker and annunciate the opening of a door. :

- 1) Top and bottom of the rectifier interior enclosure doors.
 - 2) Top and bottom of the transformer interior enclosure doors.
 - 3) Top of positive and negative disconnect switch doors.
 - 4) Top of each exterior equipment door.
- b. Separate control compartments do not require Device 33.
- c. Provide on negative and positive switches to indicate switch position.
2. Position Indication:
 - a. Breaker Closed: Illuminated red light.
 - b. Breaker Open: Illuminated green light.
 - c. Lockout relay normal position: Illuminated red light.
 - d. Lockout relay tripped: Illuminated green light.
3. Indicating lights:
 - a. LEDs used on the switchgear sections shall be of the same manufacturer and model.
- E. Intrusion Detection:
 1. Door switches:
 - a. Provide at each entry door and at each exterior equipment access door.
 2. Wire on two separate zones as follows:
 - a. Zone One: Entry doors.
 - b. Zone Two: Exterior equipment access doors.
- F. Smoke detectors:
 1. Operation: Provide alarm contact to operate lockout trip relay, ANSI Device 86 upon detection of smoke.
 2. Location: Provide at strategic locations to detect smoke or products of combustion such that operation of the circuit breakers will not activate smoke detection system.
 3. Smoke detector in MSF traction power substation shall not operate lockout trip relay.
- G. Exterior Blue light:
 1. Blue Light shall illuminate for alarms indicated in Section 34 21 31, Substation Automation System (SAS).
 2. Provide one blue light for each TPSS located on remote OCS pole, as indicated on Contract Drawings.
- H. Mobile Workstation: Provide one in each substation.
- I. Fire extinguisher:
 1. Provide two per substation.
 2. Mount to the inside wall of the substation enclosure near each entry door.

J. Dc breaker test station:

1. Provide one wall mounted unit per substation.
2. Install each test station in close proximity to circuit breakers to be tested.

K. Cable ties (tie wraps):

1. Secure cable tie mounting blocks with a screw.
2. Adhesive type mounting blocks shall not be used unless secured with a screw.

L. Dissimilar material connections:

1. Not permitted at electrical connections or connections requiring disassembly for maintenance or for removal and replacement of equipment.
2. Not permitted except at permanent connections.
3. Provide suitable electrochemical isolation.
4. Isolation treatments shall be permanent and not require maintenance or replacement for the life of the equipment or installation.

M. Insulating Materials:

1. Insulate the following with electrical insulating laminate:
 - a. Walls:
 - 1) If the clearance between the dc switchgear and wall is less than 6 feet, cover wall to full height.
 - 2) Exception: Omit electrical insulating laminate on inside surfaces of rear equipment access doors.
 - b. HVAC ducts: Cover all parts of duct with clearance from dc switchgear less than 6 feet.
 - c. Between traction power transformer and rectifier.
 - 1) Provide a continuous piece of laminate to isolate the traction power transformer from the rectifier, as indicated on Contract Drawings.
 - 2) Extend full height barrier into the room far enough to make it physically impossible for a person to touch both the traction power transformer and the dc equipment at the same time.
 - 3) Reinforce edge with a non-metallic angle or channel fastened to the floor and ceiling for stiffness.
 - d. Between rectifier and negative cubicle.
 - e. Between negative cubicle and dc feeder breakers.
 - f. Metallic surfaces:
 - 1) Within 6 feet of rectifier or dc switchgear.
 - 2) For metallic surfaces not suitable for electrical insulating laminates, such as curved surfaces, provide an alternate, such as sheet rubber or an insulated shield over the surface.

- g. Arc chutes: Provide a continuous piece of laminate on the ceiling over arc chutes of dc breakers if conductive surfaces are within 3 feet of top of dc switchgear.
 - 2. Fasteners: Secure laminate in place using non-metallic, non-conductive fasteners, in accordance with manufacturer's instructions.
- N. Identification:
- 1. Provide nameplates for equipment specified in 34 21 xx Sections in accordance with Section 26 05 00, Common Work Results for Electrical.
- O. Substation Emergency Trip Stations:
- 1. Provide three for each TPSS, two on the interior of each TPSS building next to each entrance and one on the exterior, as shown on Contract Drawings.
 - 2. Wire emergency trip station pushbuttons in a loop circuit of series wired contacts that energize a summary relay.
 - 3. Interruption of the series circuit shall cause the TPSS to shutdown by:
 - a. Tripping and locking out the main ac breaker.
 - b. Tripping and locking out all dc feeder breakers.

PART 3 - EXECUTION

3.1 FIELD INSTALLATION

- A. Requirements of Article titled "Factory Assembly" apply to field installation.

3.2 INSTALLATION OF AC SERVICE DUCTBANK TO EACH TPSS

- A. Provide underground ductbank from EPE service point to each TPSS for ac electric service.
- B. Route ductbank on Owner's property. Notify Engineer if this is not possible.
- C. Comply with requirements in EPE's Bluebook, verbal or written directives given by EPE during the required coordination with EPE, and Section 26 05 43, Underground Ducts and Raceways for Electrical Systems.

3.3 INSTALLATION OF TPSS AT PROJECT SITE

- A. Texas Department of Licensing and Regulation (TDLR):
 - 1. Comply with requirements of Texas Administrative Code (TAC) Title 16, Part 4, Chapter 70, Industrialized Housing and Buildings, including but not limited to the following:
 - a. Obtain any required permits.
 - b. Comply with installation requirements at the site.
 - c. Obtain required inspections and approval.
- B. Before setting TPSS in place, provide a sealing strip between TPSS base and concrete slab.
- C. Anchor TPSS to slab using Contractor-furnished design sealed by a structural engineer registered in the State of Texas.

3.4 TEMPORARY POWER AND HEAT

- A. Provide temporary heat within 24 hours of setting substation to prevent condensation inside the substation until permanent power is connected.
- B. Provide sufficient heat to maintain substation at 65 degrees, day and night.
- C. Provide temporary power to heater.
- D. A portable generator may be used as an alternate to temporary utility power.

3.5 MSF INTERLOCKING

- A. Design and provide an MSF interlocking system between dc disconnect-switches, dc contactors, dc breakers, ETS, and monorail crane to prevent the inadvertent energization of the OCS as described below:
- B. Bay 1:
 - 1. Disconnect switch must be closed, ETS must not be engaged, and monorail crane must be fully retracted and in "park" position for OCS to be energized.
 - 2. If disconnect switch, ETS, or monorail crane is operated, the OCS must de-energize.
- C. Bay 2:
 - 1. Disconnect switch must be closed and ETS must not be engaged for OCS to be energized.
 - 2. If disconnect switch or ETS is operated, the OCS must de-energize.
- D. Wash Bay:
 - 1. Disconnect switch must be closed and ETS must not be engaged for OCS to be energized.
 - 2. If disconnect switch or ETS is operated, the OCS must de-energize.
- E. Coordinate with crane supplier to assure that a provision for interlocking is incorporated into the crane controller design and final wiring is correct.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used.

4.2 PAYMENT

Not Used.

END OF SECTION

Technical Specification

SECTION 34 21 16 TPSS ENCLOSURES

PART 1 - GENERAL

1.1 SUMMARY

- A. Prefabricated enclosures for traction power substations (TPSS).
- B. Requirements to comply with Texas Department of Licensing and Regulation (TDLR) for prefabricated enclosures.
- C. HVAC for prefabricated enclosures.
- D. Lightning protection for prefabricated enclosures.
- E. Testing of prefabricated enclosures.

1.2 RELATED SECTIONS

- A. Section 05 05 00 – Common Work Results for Metals
- B. Section 09 67 25 – Dielectric Epoxy Flooring
- C. Section 26 05 26 – Grounding and Bonding
- D. Section 26 05 33 – Raceway and Boxes
- E. Section 34 21 05 – Common Work Results for Traction Electrification System (TES)
- F. Section 34 21 31 – Substation Automation System (SAS)
- G. Section 34 21 80 – TES Spare Parts and Special Tools
- H. Section 34 21 90 – Traction Electrification System Testing

1.3 REFERENCE STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents, or if standard is adopted by the City of El Paso, the latest revision adopted:
- B. American Institute of Steel Construction (AISC)
 - 1. AISC 303, Code of Standard Practice for Steel Buildings and Bridges
 - 2. AISC 360, Specification for Structural Steel Buildings
- C. ASTM International (ASTM)
 - 1. ASTM A36/A36M, Standard Specification for Carbon Structural Steel
 - 2. ASTM E136, Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C
- D. City of El Paso
 - 1. International Building Code (with City of El Paso amendments)

2. International Mechanical Code (with City of El Paso amendments)
3. International Energy Conservation Code (with City of El Paso amendments)
- E. Institute of Electrical and Electronics Engineers (IEEE)
 1. IEEE 1653.2, Standard for Uncontrolled Traction Power Rectifiers for Substation Applications Up to 1500 Vdc Nominal Output
- F. National Fire Protection Association (NFPA)
 1. NFPA 70, National Electrical Code (with City of El Paso amendments)
 2. NFPA 780, Lightning Protection Systems
- G. State of Texas
 1. Texas Statutes, Occupations Code, Title 7, Practices and Professions Related to Real Property and Housing, Chapter 1202, Industrialized Housing and Buildings
 2. Texas Administrative Code (TAC), Title 16, Part 4, Texas Department of Licensing and Regulation, Chapter 70, Industrialized Housing and Buildings
- H. Underwriters Laboratories (UL)
 1. UL 96A, Installation Requirements for Lightning Protection Systems

1.4 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Product Data
 1. Doors and door hardware.
 2. HVAC units.
 3. Wall seam caulking.
 4. Thermal and acoustical insulation, including weather stripping.
 5. Substation number sign.
- C. Spare Parts:
 1. Submit a list of spare parts to be provided under this Section.
 2. Submit at the same time as product data.
 3. Provide part numbers for each part, including a detailed break down of each spare part assembly and set, as defined in Section 34 21 80, TES Spare Parts and Special Tools.
- D. Shop Drawings:
 1. Detailed drawings of substation enclosure complete with all equipment and accessories in place, including layouts, arrangements, plans, sections and elevation views.
 2. Wiring and schematic diagrams of lighting, power receptacles, and heating and ventilating equipment.
 3. Detailed equipment interconnection diagrams and wiring and raceway schedules
 4. Structural details of building including support points and accessories.

5. Structural and architectural plans, elevations, sections, floor framing plan, lifting and anchorage details, erection diagrams and other prefabricated enclosure details.
 6. Enclosure base anchorage plans, floor plate, and details.
 7. Cable entrance locations and cable support system plans and details.
 8. Enclosure and equipment grounding details, including ground grid connections.
 9. Lightning protection design.
 10. Signage:
 - a. Exterior substation number designation and location.
 - b. Interior manufacturer's identification and location, if any.
- E. Bill of Materials: All components, indicating quantity, description and part number
- F. Compliance Certificates: For enclosure materials and performance
- G. Calculations:
1. Capacity of heating and ventilating units for ventilation rates, and for cooling and heating loads, certified by a mechanical engineer registered in the State of Texas.
 2. Calculations shall include tabulation of interior equipment heat gains, infiltration gains/losses, conductive gains/losses and solar gains.
 3. Structural analysis calculations for roof, wind, and seismic loadings, and of any temporary supports, certified by a structural engineer registered in the State of Texas.
 4. Structural design calculations for the enclosure, anchorage and supports, certified by a Professional Engineer registered in the State of Texas.
- H. Samples
1. Enclosure shop applied coating color samples.
- I. Substation installation instructions.
- J. Testing:
1. Submit test procedures that meet the requirements of Section 34 21 90, Traction Electrification System Testing for the following:
 - a. Factory Design Tests.
 - b. Factory Production Tests.
 2. Submit test reports that meet the requirements of Section 34 21 90, Traction Electrification System Testing for the following:
 - a. Factory Design Tests.
 - b. Factory Production Tests.
 3. Operations and Maintenance Data:

4. Submit manufacturer's operating and maintenance instructions on products specified in this Section, including the following requirements:
 - a. Building: Repair procedure for powder coat finish.
5. Submit immediately after approval of product data.

1.5 SPARE PARTS

- A. Provide spare parts in accordance with Section 34 21 80, TES Spare Parts and Special Tools.
- B. List below applies to items in this Specification Section.
 1. Lock cylinders: Keyed for traction power substation doors; provide 4 spare.
 2. Padlocks: Keyed for traction power substation equipment access doors: Provide 6 spare.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Each traction power substation enclosure shall be a shop assembled, free-standing, self supporting, steel building, utilizing channel perimeter framework and rigidly braced with channel and angle cross members.
- B. Completed assembly shall be designed for shipment for installation at site.
- C. The enclosure shall be a totally integrated weatherproof unit that houses the indicated traction power substation equipment. The enclosure shall provide a dry, vermin proof, condensation free, stable internal ambient temperature environment.
- D. Design enclosure for securing to a reinforced concrete slab as indicated on the Contract Drawings.
- E. Ratings:
 1. Complete enclosure shall have a NEMA 250 Type 4 rating.
 2. Doors, removable panels, joints, walls, roofs, floors, vents, louvers and outdoor accessories shall be weatherproof under environmental conditions specified in 34 21 05, Common Work Results for Traction Electrification System (TES).

2.2 DESIGN CRITERIA

- A. Texas Department of Licensing and Regulation (TDLR):
 1. Design and manufacturing shall comply with requirements of Texas Administrative Code (TAC) Title 16, Part 4, Chapter 70, Industrialized Housing and Buildings, under the authority of the Texas Occupations Code, Chapters 1202 and 51
 - a. TPSS buildings shall be considered industrialized buildings as defined in Chapter 1202, Section 1202.003
 - b. TPSS buildings shall be considered permanent industrialized buildings, as defined in TAC Title 16, Part 4, Chapter 70.
 - c. Manufacturer and installer shall be registered with TDLR.
 - d. Manufacturer's design package must be reviewed and approved.

- e. Conduct plant inspections complying with TDLR regulations.
 - f. Obtain and apply TDLR insignia to each building indicating that it meets TAC requirements.
- B. Structural Design:
- 1. Design enclosures and components for the service life specified in Section 34 21 05, Common Work Results for Traction Electrification System (TES).
 - 2. Design enclosure in accordance with AISC 303, AISC 360, and the International Building Code with City of El Paso amendments, to withstand live roof loading, wind loading, and seismic loading based on the service conditions specified in 34 21 05, Common Work Results for Traction Electrification System (TES) and the stresses caused during loading, transportation, unloading and installation.
 - 3. Reinforce doors, walls, and roof panels with braces, stiffeners, and structural members to provide a rigid module.
- C. Materials:
- 1. Enclosure:
 - a. Minimum No. 11 gage galvanized sheet steel as specified in Section 05 05 00, Common Work Results for Metals.
 - b. Applies to walls, roof, gutters, downspouts, entry doors, and exterior equipment access doors.
 - 2. Interior panels: Minimum 14 gage galvanized sheet steel as specified in Section 05 05 00, Common Work Results for Metals.
 - 3. Base Frame:
 - a. Structural steel to permit jacking, rolling and skidding.
 - b. Structural steel: Meet requirements of ASTM A36/A36M.
 - 4. Floor: Minimum 1/4-inch steel plate.
- D. Dimensions:
- 1. Overall substation dimensions shall not exceed those indicated on the Contract Drawings, and shall accommodate future equipment where indicated.
 - 2. Variations of the size and general layout of equipment shall be approved by the Engineer.
 - 3. Height: As low profile as possible with a minimum interior clear height of 9 1/2 feet and a maximum exterior roof height as indicated on the Contract Drawings.
 - 4. Interior working spaces and clearances: Comply with NFPA 70, Article 110, both in size and arrangement.

2.3 BASE

- A. Design: Adequate to allow lifting the complete enclosure, with all equipment in place, with a deflection not exceeding 1/240 of span.
- B. Tolerance: Level within maximum 1/8 inch in all directions.
- C. Removable lifting lugs: Provide on the base to permit lifting a fully equipped substation.

2.4 INTEGRAL FLOOR

- A. Loading design:
 - 1. Dead Load: Design for equipment weights at designed locations.
 - 2. Live Load: Design to support heaviest equipment item that would be skidded, slid, or rolled across the floor during operation or replacement, without significant deflection.
- B. Construction: Stitch weld floor plate to floor structure.
- C. Tolerance: Level and flat within maximum 1/8-inch in all directions.
- D. Penetrations:
 - 1. Provide access to cables or conduits that penetrate floors as indicated on the Drawings or as otherwise necessary.
 - 2. Provide insulated protection on edges for cable penetrations to prevent damage to cable insulation.
 - 3. Provide removable cover plates for openings:
 - a. Ac switchgear: 11 gage steel with stainless steel hardware to latch it in place.
 - b. Dc switchgear: 1/4-inch glastic with non-metallic hardware to latch it in place.
 - c. Other penetrations: 1/4-inch glastic with non-metallic hardware to latch it in place.

2.5 EXTERIOR WALL PANELS

- A. Interlock adjoining panels with J-type interlocking, as indicated in Figure 34 21 16 – 1, below.
- B. Seal seams with manufacturer recommended calking.

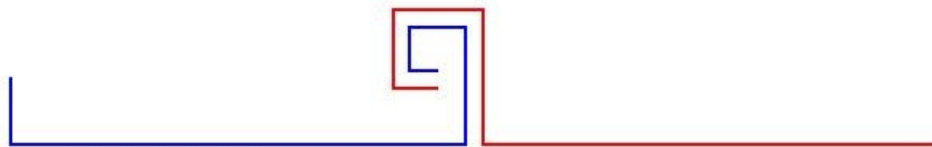


Figure 34 21 16 – 1: Cross Section Wall Panels J-Type Interlocking

- C. Provide Z-type channel at wall-panel base to prevent drain back, as indicated in Figure 34 21 16 – 2, below.

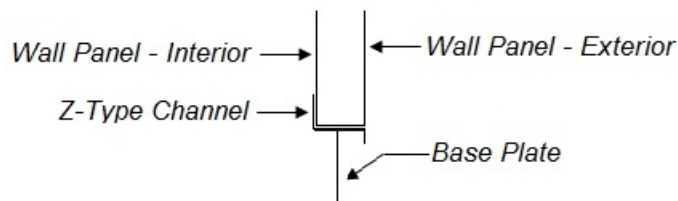


Figure 34 21 16 – 2: Cross Section Wall-Panel Base Z-Type Channel

2.6 ROOF

- A. Style: Shed type with pitch as shown on Contract Drawings.
- B. Construction:
 - 1. J-type interlocking, with standing seams and rain caps over seams, as indicated in Figure 34 21 16 – 3, below.
 - 2. Seal seams with manufacturer recommended caulking.
- C. Roof penetrations:
 - 1. Shall be used only with approval of the Engineer.
 - 2. If used, shall be minimal with each flashed and waterproofed.
- D. Gutters and Downspouts:
 - 1. Gutters: Provide one on each long side of the enclosure
 - 2. Down spouts:
 - a. Provide one at each end of each gutter, a pair for each gutter.
 - b. Design: Angle at the bottom and extend far enough from building to divert water minimum 12 inches beyond foundation slab.

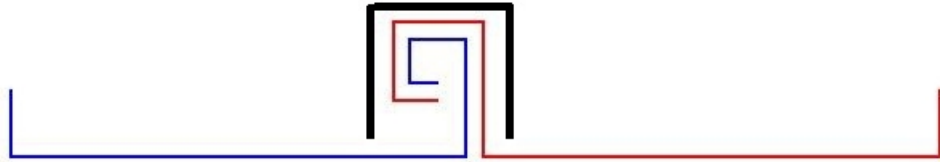


Figure 34 21 16 – 3: Cross Section Roof Panels Standing Seams With Rain Cap

2.7 FINISHES

- A. Exterior metal surfaces:
 - 1. Roof and walls: Powder coat in accordance with Section 05 05 00, Common Work Results for Metals.
 - 2. Gutters and downspouts: Powder coat in accordance with Section 05 05 00, Common Work Results for Metals.
 - 3. Floor bottom and support structure: Shop-applied paint coating system in accordance with Section 05 05 00, Common Work Results for Metals.
 - 4. Color: See Section 05 05 00, Common Work Results for Metals.
- B. Interior metal walls and ceiling:
 - 1. Powder coat in accordance with Section 05 05 00, Common Work Results for Metals.
 - 2. Color: See Section 05 05 00, Common Work Results for Metals.

C. Interior floor surfaces:

1. Shop-applied paint coating system in accordance with Section 05 05 00, Common Work Results for Metals.
2. Dielectric epoxy floor, where indicated on Contract Drawings, in accordance with Section 09 67 25, Dielectric Epoxy Flooring.
3. Floor shall have a non-skid finish.
4. Color: Shop-applied paint coating system shall match color of dielectric epoxy flooring. See Section 09 67 25, Dielectric Epoxy Flooring.

2.8 DOORS

A. Entry doors:

1. Enclosure shall have a minimum of two entry doors, located as indicated on the Contract Drawings.
2. Entry doors shall not be smaller than as shown on the Contract Drawings.
3. Size and build one set of doors with a removable transom to permit removal of the largest piece of equipment in the substation that is not removable through exterior equipment access doors.

B. Entry Door Hardware:

1. Panic hardware: Provide one or three point crash-bar safety latches to permit opening doors from within under all conditions.
2. Locks: Self-locking, tamper proof, integrated with entry handles.
3. Keying: Key substations alike with master keyed locks and provisions for re-keying. The Engineer will provide final keying requirements.
4. Door Closer:
 - a. Heavy duty, highly corrosion resistant; all external body components of aluminum, zinc alloy or stainless steel material with stainless-steel fasteners.
 - b. Shall close door firmly and have hold-open position.

C. Exterior Equipment Access Doors:

1. Provide behind equipment requiring access for cable makeup or maintenance, and as required by Sections 34 21 19, Dc Switchgear and 34 21 23, Transformer-Rectifier Unit.
2. Doors 36 inches or wider shall include vertical stiffeners, minimum 3 stiffeners for a 36-inch door, with one additional stiffener for each additional 12 inches of door width.

D. Exterior Equipment Access Door Hardware & Relays

1. Operating handles: Padlockable, located at working height referenced to actual final grade elevation at site.
2. Padlocks: Provide a master keyed padlock for each rear equipment access door.
3. Door closers: Provide door closers for each entry door.
4. Door stops: Provide a door stop for each door to hold it in the open position.

5. Provide ANSI device No. 33E microswitch on doors. Upon opening of a door, provide the following:
 - a. Alarm to SAS. See Section 34 21 31, Substation Automation System (SAS).
 - b. Trip the ac lockout relay, ANSI Device 86 and dc lockout device 186.

2.9 ENTRY STEPS

- A. Provide landings and stairs as indicated on Contract Drawings.

2.10 GROUNDING PADS

- A. Provide four copper grounding pads, grounded to the frame of the enclosure on the interior corners of the complete enclosure as indicated on the Contract Drawings, for connection of 2-hole cable lugs.
- B. Provide penetrations in floor for access, with removable cover plates as described above in Article titled "Integral Floor."
- C. Connect enclosure grounding pads to enclosure interior perimeter ground specified in Section 26 05 26, Grounding and Bonding.

2.11 HEATING, VENTILATING AND AIR CONDITIONING (HVAC)

- A. Interior Environment:
 1. Provide thermostatically controlled HVAC system to prevent condensation and maintain the interior temperature between 65 degrees F and 77 degrees F under all operating conditions.
 2. Provide two HVAC units with economizer cycle.
- B. General Requirements:
 1. HVAC system shall comply with the International Mechanical Code with City of El Paso amendments.
 2. HVAC units shall be controlled by the same thermostat and control unit.
 3. High Temperature Alarm:
 - a. If substation interior temperature reaches 85 degrees F send alarm to SAS. See Section 34 21 31, Substation Automation System (SAS).
 - b. Alarm temperature set point shall be field adjustable.
 4. Supply voltage: Either 120 Vac or 208/240 Vac, single-phase.
 5. Finish color: Match finish color of substation enclosure.
- C. HVAC Units: Unitary, packaged, wall-mounted type, hermetically-sealed compressors, UL listed, AHRI performance certified, meeting minimum efficiency requirements of the International Energy Conservation Code with City amendments.
- D. Ventilation and Air Conditioning: Design system for heat gain in the substation under the following simultaneous conditions.
 1. Maximum loading of the traction power transformer per IEEE 1653.2 for Light Traction Service.

2. Exterior design conditions per International Energy Conservation Code with City amendments.
 3. Maximum solar heat gain.
- E. Ventilation system shall provide sufficient air changes during heating periods to prevent battery-evolved hydrogen gases from exceeding a 1 percent concentration level.
- F. Heating: Design based on conduction and infiltration heat loss with exterior design conditions per International Energy Conservation Code with City amendments and substation de-energized (no heat gain from interior equipment).
- G. Air Intakes:
1. Grill: Provide over filter to prevent entrance of foreign objects.
 2. Filters: Provide micro-glass, high-efficiency disposable filters in filter frames.
 3. Exterior: Provide tamper-proof hardware for filters located on exterior of enclosure.
- H. Provide two HVAC units for each substation enclosure with each unit capable of maintaining the interior environment specified above.
- I. Economizer Cycle Cooling:
1. Provide HVAC units in conjunction with an exhaust fan to allow cooling using only exterior air when that air is less than 60 degrees F.
 2. Equip inlet and exhaust ducts for economizer cooling with gasketed, motorized dampers to seal the enclosure when economizer cooling is not possible.
 3. Economizer design shall maintain zero or slightly positive pressure within the substation building at maximum ventilation rate.
- J. Redundant Operation:
1. HVAC units shall operate with one unit on standby.
 2. Failure of the operating unit shall cause the other unit to commence operation automatically.
 3. Provide controls to manually and automatically alternate the units to minimize wear on each unit.

2.12 THERMAL AND ACOUSTICAL INSULATION

- A. General Requirements:
1. Insulating materials shall have a certified classification of "non combustible" as defined by ASTM E136.
 2. Flame proofing of insulating materials will not be acceptable. Proof of certification shall be by one of the following:
 - a. UL label or listing.
 - b. National Bureau of Standards test results.
 - c. Certified test report from a nationally recognized testing laboratory.

- B. Thermal Insulation:
 - 1. Comply with International Energy Conservation Code with City amendments for Climate Zone 3.
 - 2. Floor: Solid insulating panels.
- C. Acoustical insulation: Provide where needed to control continuous sound levels outside substations.

2.13 LIGHTNING PROTECTION

- A. Provide lightning protection conforming to the requirements in NFPA 780 and UL 96A for ordinary buildings less than 75 feet in height, utilizing air terminals.
- B. Materials shall be UL listed for the purpose.
- C. Air terminals (lightning rods) shall be solid copper with the following minimum heights:
 - 1. Type 1: 12 inch.
 - 2. Type 2: 24 inch.
- D. Connect air terminals to the building framework by short runs of conductors.
- E. Main, secondary and bonding conductors:
 - 1. Stranded copper conductors concealed in RTRC meeting the requirements of Section 26 05 33, Raceway and Boxes.
 - 2. Paint conduit to match building color.
- F. Bolt or weld the steel framework and cladding to make electrically continuous.
- G. Bond pipes, including vent pipes, using ground clamps with lugs.
- H. Submit design for approval.

2.14 SIGNAGE

- A. Substation Number Sign: Provide on two sides of the enclosure in location approved by Engineer.
 - 1. Sign material: Baked porcelain enamel, as specified in Section 34 21 05, Common Work Results for Traction Electrification System (TES), in Article titled "Warning Signs."
 - 2. Color: Black lettering on a white background, or as directed by Engineer.
 - 3. Number designation: "TPSS – XX," where "XX" is a number that will be provided by the Engineer.
 - 4. Lettering height: 6 inches, minimum.
 - 5. Location: As approved by Engineer.
 - 6. Attachment hardware: As specified in Section 34 21 05, Common Work Results for Traction Electrification System (TES), in Article titled "Warning Signs."
- B. Manufacturer's Name: Shall not be placed on the exterior of the enclosure. It will be allowed on the interior of the enclosure but shall be approved by the Engineer.

2.15 SOURCE QUALITY CONTROL

A. Factory Design Tests:

1. Coating qualification test: Perform in accordance with IEEE C37.20.1.

B. Factory Production Tests:

1. Rain test for outdoor LV switchgear: Perform on each substation in accordance with IEEE C37.20.1. An existing design test will not be accepted; this test will not be waived.
 - a. In addition to IEEE C37.20.1 requirements, address HVAC systems as follows:
 - 1) Test first with HVAC systems installed but not operating.
 - 2) If HVAC systems have louvered openings that open when the system is in operation, retest with all such openings in the fully open position.
 - b. Replace IEEE C37.20.1 satisfaction of test requirements with the following: the enclosure shall have satisfactorily met the requirements of this test if during the visible inspection no water is found.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation of HVAC units after building delivery shall comply with the following:

1. International Mechanical Code with City of El Paso amendments.
2. NFPA 70 with City of El Paso amendments.

B. Provide condensate drain pipe for HVAC units.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 34 21 19 DC SWITCHGEAR

PART 1 - GENERAL

1.1 SUMMARY

- A. Work included in this Section is for the following dc switchgear sections for traction power substations:
 - 1. Negative switch (89N) and positive switch (89P) sections.
 - 2. Feeder breaker sections.
- B. Number of dc circuit breakers and the configuration of each traction power substation are shown on the Contract Drawings.

1.2 RELATED SECTIONS

- A. Section 05 05 00 – Common Work Results for Metals
- B. Section 09 67 25 – Dielectric Epoxy Flooring
- C. Section 26 50 00 – Lighting
- D. Section 34 21 05 – Common Work Results for Traction Electrification System (TES)
- E. Section 34 21 25 – TPSS Dc Control Power
- F. Section 34 21 31 – Substation Automation System (SAS)
- G. Section 34 21 73 – TE System Studies
- H. Section 34 21 80 – TES Spare Parts and Special Tools
- I. Section 34 21 90 – Traction Electrification System Testing

1.3 DEFINITIONS

- A. Intelligent Electronic Device (IED): See definition in Section 34 21 05, Common Work Results for Traction Electrification System (TES).

1.4 REFERENCE STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents:
- B. Institute of Electrical and Electronics Engineers (IEEE)
 - 1. IEEE C37.14, Standard for Low-Voltage Dc Power Circuit Breakers Used in Enclosures
 - 2. IEEE C37.16, Standard for Preferred Ratings, Related Requirements, and Application Recommendations for Low-Voltage Ac (635 V and below) and Dc (3200 V and below) Power Circuit Breakers
 - 3. IEEE C37.20.1, IEEE Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear

1.5 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Product Data: Complete manufacturer's product descriptions and catalog data, including information on the following:
 - 1. Design and application ratings.
 - 2. Details of circuit breaker, internal components, arc chute, contacts, and closing and tripping mechanisms.
 - 3. Details of switchgear, drawout mechanism, interlocks, and shutters.
 - 4. Relays, controls, switches, indicators, load measuring devices, resistors and cubicle heaters.
 - 5. Key Operated Mechanical Interlock: Kirk key catalog data.
 - 6. Bus insulating material.
 - 7. Certified service performance, reliability and 5-year proven service history record, including a complete device history of the following:
 - a. Multi-function relays.
 - b. Circuit breakers.
- C. Spare Parts and Special Tools:
 - 1. Submit a list of spare parts to be provided under this Section.
 - 2. Submit at the same time as product data.
 - 3. Provide part numbers for each part, including a detailed break down of each spare part assembly and set, as defined in Section 34 21 80, TES Spare Parts and Special Tools.
 - 4. Submit a list of special tools to be provided under this Section, as defined in Section 34 21 80, TES Spare Parts and Special Tools.
- D. Shop Drawings:
 - 1. Arrangement drawings.
 - 2. Schematic wiring diagrams.
 - 3. Interconnection diagrams.
 - 4. Bus insulating drawings.
- E. Complete details of transfer trip scheme.
- F. Kirk key scheme, including description, and detailed arrangement drawings.
- G. Testing:
 - 1. Submit test procedures that meet the requirements of Section 34 21 90, Traction Electrification System Testing for the following:
 - a. Factory Design Tests.
 - b. Factory Production Tests.

2. Submit test reports that meet the requirements of Section 34 21 90, Traction Electrification System Testing for the following:
 - a. Factory Design Tests.
 - b. Factory Production Tests.
- H. Operations and Maintenance Data:
 1. Submit manufacturer's operating and maintenance instructions on products specified in this Section, including the following:
 - a. Submittal information identified above.
 - b. Manufacturer's operating and maintenance instructions, parts list, illustrations and diagram for components.
 - c. Wiring diagram.
 2. Submit immediately after approval of product data.

1.6 SPARE PARTS

- A. Provide spare parts in accordance with Section 34 21 80, TES Spare Parts and Special Tools.
- B. List below applies to items in this Specification Section.
 1. Dc circuit breaker: Complete with truck and accessories. Provide 3 spares.
 2. Main contacts for dc circuit breaker: Provide 2 spare assemblies.
 3. Secondary contacts for dc circuit breaker: Provide 2 spare assemblies.
 4. Dc circuit breaker charging motors: Provide 2 spares.
 5. Dc circuit breaker solenoids: Provide 2 spares.
 6. Dc circuit breaker springs: Provide 2 spares.
 7. Dc protective relays (non-IED): Provide 1 spare set.
 8. Dc switchgear IEDs: Provide 1 spare set.
 9. Dc ammeter and voltmeter: Provide 1 spare set, if separate from IEDs.
 10. Dc switchgear control and auxiliary relays: Provide 1 spare set.
 11. Transducers: Provide 1 spare set.
 12. Dc switchgear control circuit fuses (if used): Provide 5 spare sets.
 13. Dc mini circuit breakers (if used): Provide 1 spare of each rating.
 14. Mechanical interlocks: Provide 1 spare set.

1.7 QUALITY ASSURANCE

- A. Dc Switchgear:
 - 1. UL labeled or furnished with a Field Evaluation label in accordance with Section 34 21 05, Common Work Results for Traction Electrification System (TES).
 - 2. Dc switchgear including circuit breaker shall have 5 years successful operation in service at a transit application.
- B. Manufacturers of dc switchgear and components used in the dc switchgear shall be ISO 9001 certified.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Dc Switchgear: Dead-front, self-ventilated, metal enclosed, free standing, sheet steel enclosures suitable for indoor service.
- B. Circuit Breakers: Provide switchgear with individually enclosed, draw out type, high speed, power circuit breakers rated for use with the transformer-rectifier unit.
- C. Rear Access:
 - 1. Prefabricated TPSS: Provide through exterior equipment doors and design such that positive feeder cables and negative return cables can be landed from the rear.
 - 2. MSF TPSS: No rear access.
- D. Front Access:
 - 1. Prefabricated TPSS: Provide access to removable components of the switchgear from the front.
 - 2. MSF TPSS: Provide access for landing positive and negative cables and access to removable components of the switchgear.
- E. Bus and Power Wiring:
 - 1. Prefabricated TPSS: Locate in rear.
 - 2. MSF TPSS: Locate in rear, accessible from front.
- F. Complete Assembly: Include dc buses and connections, positive and negative feeder cable terminal connections, indicating lights, terminal blocks, protective and auxiliary relays, control circuitry, wiring and all other devices necessary to make a complete and operable switchgear assembly.
- G. Workmanship: Avoid wiring congestion, train wires neatly, and protect wiring from sharp edges.
- H. Standards: Design, materials, construction, and tests shall be in accordance with IEEE C37.14, IEEE C37.20.1, and as further described or modified in this Section.
- I. Finish: Powder coat and color in accordance with Section 05 05 00, Common Work Results for Metals.

2.2 RATINGS

- A. The switchgear assembly and circuit breakers shall have the following minimum ratings in accordance with IEEE C37.14 and IEEE C37.16:

Full-Load Voltage	750 Vdc
Maximum Voltage	1000 Vdc
Continuous Current	1000 A
Minimum Frame Size	1000 A
Insulation Level:	
60 Hz withstand	3.7 kV rms
Short circuit rating	30 kA, peak

2.3 SWITCHGEAR ENCLOSURE

- A. Switchgear Structure:
1. Steel, rigid, self-supporting, self-contained, conforming to IEEE C37.20.1 and to requirements indicated below:
 2. Fabricated of electrically welded or bolted sheet steel, 11 gage minimum.
 3. Provide enclosures sufficiently rigid to support equipment under normal loads, short-circuit conditions, and specified seismic conditions.
 4. Apply coating to switchgear assembly in accordance with Section 05 05 00, Common Work Results for Metals.
- B. Doors: Sheet steel, 11 gage minimum, properly reinforced against distortion by suitable flanges and stiffening members.
1. Hinges: Heavy duty stainless steel.
 2. Latches: Minimum of three latches shall securely fasten door in the closed position and shall be easily opened without the use of tools.
 3. Handle: Heavy duty, padlockable, opens all three latches, easily operated with one hand-motion, one for each door.
 4. Door stops: Heavy duty to hold door securely in the open position. Not easily bent if an attempt is made to close door without releasing door stop.
- C. Heaters: Provide two thermostatically-controlled strip-type heaters in each switchgear cubicle to prevent condensation.
1. Operating Voltage: Shall not exceed 50 percent of heater rated voltage.
 2. Thermostat:
 - a. Provide an individual thermostat for each cubicle.
 - b. Locate thermostat in a general area of each cubicle so that cool air at the lower portion of the enclosure can be sensed by the thermostat.
 3. Digital Heater Ammeter: Provide on the front of each cubicle enclosure to indicate current and operation of heaters.
 4. Power Source: 120 Vac auxiliary power system; use an isolation transformer.

- D. Lights: Provide inside equipment enclosures, as specified in Section 26 50 00, Lighting.
- E. Warning Signs:
 - 1. Provide signs on front, rear, and side access doors of cubicles where 600/750 Vdc wiring is present: "DANGER: LIVE PARTS" and "DANGER: HIGH VOLTAGE."
 - 2. Provide signs on removable rear access doors: "DANGER: HIGH VOLTAGE."
- F. Dc circuit breaker cubicle:
 - 1. Suitable for accommodation of drawout circuit breakers.
 - 2. Supporting Guide Rails: Provide for positioning removable elements as an integral part of equipment.
 - 3. Design such that circuit breakers are easily drawn in or out of their housings.
 - 4. Include stationary disconnecting device contacts for the circuit breakers.
 - 5. Breakers shall connect or disconnect from buses and auxiliary circuits by means of self-aligning, self-coupling, primary disconnecting devices.
 - 6. Provide self alignment mechanisms such that misalignment of contact is not possible when circuit breaker elements make contact with stationary contacts.
 - 7. Control Wiring: Connection to the dc breaker may be by movable contacts or by a plug-style disconnect.
 - a. Plug style disconnect:
 - 1) It shall not be mechanically possible to rack breaker into the connected position with the plug disconnected.
 - 2) Locate where easily accessible. Engineer will make final determination whether location is easily accessible.
 - 3) Provide heavy-duty connection hardware not easily bent or broken due to mishandling.
 - 8. Provide suitable shrouds or automatic safety shutters on devices to prevent accidental contact with live parts.
 - 9. Provide each enclosure with protective shutters that cover live high-voltage terminals when the access door is opened or a dc feeder breaker is racked out of the cubicle.
 - 10. Provide each compartment with a hinged door or full width drawout panel for front access to the circuit breakers, instruments and terminal blocks.
 - 11. Provide rear access doors in prefabricated TPSS to facilitate access to the dc power bus. Doors shall swing fully open against the adjacent door or enclosures.
 - 12. Provide connections to the dc feeder cables in the rear compartment.
 - 13. Construct switchgear enclosures to allow for the dissipation of ionized gas from the circuit breaker arc chutes without hazard to personnel from the discharge of hot gas or other materials.
 - a. Release gas from the units to the outside of the switchgear enclosure by means of suitable stacks, louvered vent openings, or vent openings covered with grilles.

- b. Provide adequate clearance to ground to prevent the possibility of establishing a conducting path to grounded structure or objects when interrupting maximum short-circuit energy at rated maximum voltage.
 - c. Line enclosure surfaces exposed to arcs or ionized gases with flame resistant, high dielectric insulating materials.
 - d. This paragraph is not intended to require the use of arc-resistant switchgear.
- 14. Stacking of dc circuit breakers in cubicles is not permitted.
- G. Negative and Positive Switch Cubicles:
 - 1. Mount positive and negative switches in separate isolated cubicles, either stacked or side by side.
 - 2. Negative switch may be provided as part of rectifier but must be isolated from rectifier.
 - 3. Cubicles shall have a hinged door with a clear window for viewing negative or positive switch position.
- H. Separate high voltage devices from low voltage controls:
 - 1. If high voltage devices and low voltage controls are located in the same cubicle, identify high and low voltage by color coding mounting panels.
 - 2. No controls are allowed in rear cable and bus compartment.
- I. The control devices can share the same compartment with the protection devices.
 - 1. Control/protection compartment shall be dead-front and shall consist of hinged swinging panels mounted on the switchgear frame.
 - a. Construct swinging panel doors to support flush and semi-flush mounted devices.
 - b. Swinging panel doors shall not distort from a plane surface in any position.
 - c. Swinging panel doors of control/protection compartment shall be supported by stainless steel hinges.
 - d. Panel doors shall swing open and provide free access to the area behind the panel, the rear of the devices mounted on the panels, wiring, terminal blocks, and auxiliary devices mounted within the compartment.
 - e. Secure swinging panel doors in the closed position with two positive latching or screwed fasteners that can be operated by hand without tools.
 - f. Swinging panel doors shall open 90 degrees and be held with heavy duty stops.

2.4 BUS AND BUS CONNECTIONS

- A. Main horizontal dc switchgear bus shall be an extension of the rectifier bus, run the length of the dc switchgear. Tap to serve each circuit breaker.
- B. Bus: Electrical grade copper with high electrical conductivity, rated 1000 A.
- C. Bolted bus connections: Silver-plated copper.
 - 1. All connections to the bus shall be bolted.
 - 2. Applies to bus taps, circuit breaker connections, cable connections, and connections of devices such as transducers and shunts.

3. Bolts: Silicon bronze of sufficient number and size for application. Minimum two bolts per joint.
4. Washers: Provide a Belville washer for each bolt, properly sized for the application.
5. Conductivity: Each joint shall have conductivity at least equal to that of the bus bar and shall be so clamped that no loss of conductivity will occur during the life of the switchgear.

D. Insulation:

1. Insulate main bus and feeder bus from each other by one of the following means:
 - a. Electrical insulating laminate barrier that completely encloses bus on both sides and both edges.
 - b. Insulating boot.
 - c. Insulated coating.
 - d. Other approved means.
2. Insulate connections to the bus using a boot.
3. Mount bus bars on barrier-type insulation or post-type insulators.

- E. Strength: Bus, bus connections, and bus insulation shall withstand thermal and mechanical stresses resulting from maximum available short-circuit current or rms interrupting rating of circuit breakers whichever is greater, without damage or permanent distortion.

2.5 POSITIVE AND NEGATIVE DISCONNECT SWITCHES

- A. Provide a negative dc disconnect switch (Device 89N) and a positive dc disconnect switch (Device 89P) in each substation dc switchgear assembly, as shown in Contract Drawings. Each switch shall meet the following requirements:
1. Type: Manually-operated, single-pole, bolted-pressure type, solid copper blade with silver plated contacts.
 2. Rating: 1000 A continuous current at 1000 Vdc and withstand twice the expected rms bolted short circuit currents.
 3. Insulation level: Sufficient to pass 1 minute 60 Hz dry withstand test at 3.7 kV, rms.
 4. Handle: Provide an insulated operating handle.
 5. Switch Position Indication:
 - a. Provide a green and a red indicating light on the front panel of cubicle for each switch:
 - 1) Green illuminated: Switch open.
 - 2) Red illuminated: Switch closed.
 - b. Provide indication to SAS; see Section 34 21 31, Substation Automation System (SAS).
 - c. See Section 34 21 05, Common Work Results for Traction Electrification System (TES), for requirements for Device 33 position switch.
 6. Instructions: Provide a simple operation instruction nameplate on each cubicle door.

B. Negative Disconnect Switch – 89N:

1. Connection: Install between the negative return cable and the rectifier negative pole.
2. Interlock with Positive Switch:
 - a. Provide key interlock with positive disconnect switch to ensure negative switch can be opened only when positive switch is open.
 - b. Key removal from the negative disconnect switch shall be possible only when the negative disconnect switch is closed.
 - c. Opening of negative disconnect switch shall require the key to be inserted in the negative disconnect switch.
3. Interlock with Dc Circuit Breakers:
 - a. If negative switch is in the open position it shall not be possible to close a dc circuit breaker.

C. Positive disconnect switch – 89P:

1. Connection: Install between the rectifier output and the dc feeder breakers.
2. Interlock with Negative Switch:
 - a. Key interlock with the negative switch to prevent positive switch from closing when the negative disconnect switch is open.
 - b. Key shall not be removable from the positive switch when the negative disconnect switch is closed.
 - c. With the key removed from the positive switch it shall be mechanically locked open.
3. Interlock with Ac Switchgear: Key interlock to ensure no-load opening.

2.6 CIRCUIT BREAKERS

A. Dc circuit breakers: Single-pole, air-break, high-speed, removable type.

1. Manufacture in accordance with IEEE C37.14, and rate according to the preferred ratings listed in IEEE C37.16, except as indicated in this Section.
 - a. As an alternate, provide dc circuit breakers tested according to IEC 60077 Parts 1 and 3.
2. Suitable for local and remote supervisory control.
3. Electrically operated and electrically and mechanically trip-free with the mechanism insuring full contact pressure until time of opening.
4. Insulated to withstand 3.7 kV, rms at 60 Hz for 1 minute.
5. Peak rated momentary current: 30 kA, minimum.

B. Instantaneous (Device 76): Provide each dc feeder circuit breaker with a direct-acting, bi-directional, instantaneous overcurrent tripping device adjustable between 150 percent and 350 percent of the breaker rating.

C. Contacts:

1. Surfaces of the moving and stationary contact members of the main contacts shall be silver, non-welding silver alloy, or equivalent that combines high conductivity and necessary arc-resistant properties.
2. Main and secondary contacts of breaker shall be removable for replacement.

D. Operating mechanism:

1. Solenoid-operated or motor-charged stored-energy, spring-operated type.
 - a. Connect solenoid operated mechanisms such that the control voltage is removed from the closing coil after a preset time.
 - b. In the event the breaker does not close or the closing control circuit is not opened, a trip sequence shall be initiated to open the closing control circuit and restore all closing sequence relays to their normal position.
 - c. Motor-charged and spring-operated mechanisms:
 - 1) Mechanism shall be designed to prevent overcharging.
 - 2) The mechanism shall ensure that the release of stored energy for closing the circuit breaker main contacts is prevented unless the mechanism has been fully charged.
 - 3) The stored-energy closing mechanism shall automatically charge itself within 15 seconds after closing of the breaker.
 - 4) Energy storage shall be sufficient for an open-close-open cycle at maximum rated short circuit current.
2. Mechanism shall be non-pumping.
3. Design shall ensure positive opening of the moving contacts and circuit interruption when the tripping impulse is received at the fully closed or any partially open position.
4. Provide control with a shunt trip device with the necessary auxiliary control equipment.

E. Breaker Position: Make provisions for moving each breaker to a "connected", "test" and "disconnected" position with positive stops in each position.

1. "Connected" position: Both the primary disconnecting devices and the secondary disconnecting devices shall be in full contact and the breaker shall be in position for normal operation.
2. "Test" position: Primary disconnecting devices shall be open and separated by a safe distance and the secondary disconnecting devices shall be in full contact.
3. "Disconnected" position: Both primary and secondary disconnecting devices shall be open and separated by a safe distance and shutter closed.
4. Position Indicator: Provide an indicator to show the location of the circuit breaker in "connected," "test," or "disconnected" positions.

F. Mechanical and Electrical Interlocks:

1. Mechanical:

- a. Provide interlock to prevent moving circuit breaker in or out of the "connected" position when circuit breaker main contacts are in the closed position.
- b. Provide interlock to prevent closing the circuit breaker manually unless the breaker is in the "test" or "disconnected" position.

2. Electrical:

- a. Provide interlock to prevent closing circuit breaker electrically, unless the circuit breaker is in the "connected" position with the primary disconnecting devices in full contact, or in the "test" position.

G. Breaker Control:

1. Breaker control switch: Incorporate into SAS HMI. See Section 34 21 31, Substation Automation System (SAS), for additional information.

- a. Request to close a dc feeder breaker shall be governed by the load measure reclose system. See Protective Devices article, below, for details of the load measure reclose system.
- b. Provide sufficient logic to ensure that a response to an HMI or remote supervisory closure request will not result in an unsafe condition or cause damage to the substation or any of its components.

2. Bypass Load Measuring:

- a. Provide control on SAS HMI that allows an authorized operator to bypass load measure system when closing breaker.
- b. See Section 34 21 31, Substation Automation System (SAS) for details of operation.

3. Manual trip:

- a. Provide each circuit breaker with mechanical means for manually tripping the circuit breaker in the "test" and "connected" positions.
- b. This function shall be available with the compartment door closed.

4. Control power: Provide from 125 Vdc control power system per Section 34 21 25, TPSS Dc Control Power.

H. Indication:

1. Electrical:

- a. Provide red and green indicating lights on each breaker unit for electrical closing and opening of the breaker while in the "test" or "connected" positions.
 - 1) Red light illuminated: Breaker closed.
 - 2) Green light illuminated: Breaker open.
 - 3) Provide long life, high brightness and high visibility, LED array lights.
- b. Provide indication to SAS; see Section 34 21 31, Substation Automation System (SAS).

2. Mechanical: Provide a mechanical indicator, visible when the door is closed, to show when the circuit breaker is in the "open" and "closed" condition.
- I. Auxiliary Contacts:
 1. Provide a minimum of four electrically separate sets of reversible auxiliary contacts, in addition to those required for the circuit breaker control circuit.
 2. Auxiliary contacts shall be operated by the breaker mechanism in both the "connected" and "test" position.
 3. Spare auxiliary contacts shall be wired to the outgoing terminal blocks.
 - J. Arc chutes:
 1. Metal plate or magnetic coil type.
 2. Suitable for bidirectional current flow.
 3. Designed for positive interruption of currents from 0 A to circuit breaker maximum rating.
 4. Provide with an air puffer device to extinguish low-current arcs.
 - K. Operations Counter: Provide four digit, non-resettable, register type mechanical operations counter on each circuit breaker to record tripping operations.
 - L. Lockout Provisions:
 1. Provide means to permit padlocking the dc breaker in the open position to prevent inadvertent closure without having to withdraw the breaker element.
 2. Padlocking means shall not allow breaker to be inserted further than the test position.
 - M. Breaker Truck Wheels:
 1. Provide circuit breakers with approved wheels to remove element from cubicle.
 2. Fifth Wheel:
 - a. If breaker truck cannot be easily turned when outside the breaker cubicle, provide a fifth wheel.
 - b. Engineer will make the determination whether breaker truck can be easily turned.
 - c. Wheels shall not damage epoxy floor coating.
 - N. Interchangeability:
 1. Removable elements of the same type and rating shall be completely physically and electrically interchangeable.
 2. Removable elements not of the same type of rating shall not be physically interchangeable.

2.7 TPSS DC CABLE CONNECTIONS

- A. Bottom or top feed for negative and positive dc feeders, as required.
- B. Provide ample space for pulling and terminating the feeder cables entering or leaving the switchgear without requiring a less than specified cable bending radius.
- C. Provisions shall be made for the termination of up to four 250 kcmil, 2 kV dc positive cables in each feeder breaker section.

- D. Provide for the termination of up to eight 250 kcmil, 2 kV dc negative return cables on load side of the negative disconnect switch.

2.8 PROTECTIVE DEVICES

A. General Requirements:

1. Protective relays and multifunction relays provided in dc switchgear shall be Intelligent Electronic Devices (IED) equipped with communication function.
2. Alarm Communication: Send alarms to SAS via protocol specified in Section 34 21 31, Substation Automation System (SAS).
3. Built-in Functions: Control, measurement and fault recording.
4. Screens: LCD.
5. Time Synchronization: Protective IEDs shall synchronize time with SAS.
6. Protective Device Coordination: Perform a coordination study for the dc system in accordance with Section 34 21 73, TE System Studies to obtain preliminary relay settings.
7. Final Settings: Make final adjustments to relaying systems and protective devices during TPSS Field Acceptance Testing and Integrated Testing specified in Section 34 21 90, Traction Electrification System Testing.
8. Contact Wire Thermal Rise: Set instantaneous and sustained current curves to limit the contact wire thermal rise to less than 165 degrees F.
9. Complete Installation: Provide additional components such as auxiliary relays, isolating diodes and similar devices not shown in the Contract Drawings, but required for a complete installation.

B. Arrangement and Appearance:

1. Arrange devices such as auxiliary relays, indicating lights and test plugs to be conveniently accessible and easily visible.
2. IED meters and displays shall be located such that they are easy for a person standing at floor level to operate and read.
3. The grouping shall be modular and place related functions in proximity.
4. Mount devices plumb and square with the lines of the panels and mount as recommended by the manufacturer and approved by Engineer.
5. Auxiliary devices shall match the general appearance as far as possible with frames of a compatible approved color and finish.
6. Devices of the same general type shall be manufactured by the same company and shall be similarly arranged and mounted.
7. Refer to substation one-line diagram in the Contract Drawings for arrangement of protective relays and devices.

C. At a minimum, provide the following protective functions/devices as shown below and on the substation one-line diagram in the Contract Drawings. Additional protective functions/devices recommended by equipment manufacturers may be installed with Engineer approval.

1. Dc Feeder Multifunction Relay IED:
 - a. Acceptable Manufacturer/Product: Siemens Sitras Pro, or approved equal.

- b. Functions: Include the following at minimum:
- 1) Overcurrent: At minimum, provide the following overcurrent protection functions, which shall operate in the forward and reverse current directions:
 - i) Instantaneous Overcurrent Trip.
 - ii) Low Level Fault Trip and associated time delay.
 - iii) Timed Overcurrent Trip:

Provide timed overcurrent trip function with inverse time characteristic that can be graphed with the set current, I_{tmd} , as the y-axis, and the time delay, T_{mdDel} , as the x-axis.

Tripping shall be initiated when the load current exceeds the set current during the period of time t such that (t / T_{mdDel}) and (I_{load} / I_{tmd}) correspond to a point on the curve.
 - 2) Rate of Rise Trip: Shall be initiated if all of the following conditions are met:
 - i) Current di/dt exceeds the trip limit, di/dt .
 - ii) Di/dt stays above the trip limit during the delay time, Delay.
 - iii) During the delay time current exceeds the current rise limit.
- c. Load Measure and Reclose:
- 1) Provide each dc feeder cubicle with a set of automatic reclosing functions and equipment, including the following:
 - i) Load measuring function (Device 82).
 - ii) Adjustable time delay reclosing function (Device 83).
 - iii) Load measuring resistors mounted on the top of the circuit breaker cubicle;
 - iv) Associated accessories.
 - 2) Initiate the load measuring and automatic reclosing cycle when either the dc circuit breaker receives a "close" command (from the local or remote control), or when the circuit breaker is tripped automatically and attempts to reclose.
 - 3) A "lockout" status or intentionally initiated trip of the dc lockout relay shall disable the load measuring and automatic reclosing cycle.
 - 4) Precede initiation of the load measuring cycle by an adjustable time delay to permit the faulted line section to become fully deenergized.
 - 5) At the commencement of the load measurement cycle, a voltage sensor shall determine whether there is no voltage on the section.
 - 6) If the voltage measuring circuit detects potential on the section, it shall reclose the associated circuit breaker immediately, providing that this potential is greater than a preset value.

- i) The pickup setting shall be adjustable over the range of 60 to 750 Vdc.
 - ii) Initially the pickup voltage shall be set to 560 Vdc.
- 7) If the voltage measuring circuit detects no potential on the section, the load measuring function shall make repeated load measurements at suitable adjustable time intervals.
- 8) If a load measurement determines that no fault is present, initiate automatic reclosing of the circuit breaker.
- 9) A successful reclosure with no automatic trip within five seconds shall complete the measurement cycle and reset the devices to their initial state.
- 10) Make provision for selection of up to six attempts to complete a successful load measurement and automatic reclosing cycle at 15 second intervals, within a 3 minute period. Set initially at three attempts.
- 11) If no successful reclosure takes place in the three minute period, the automatic reclosing and load measuring system shall lock out the feeder breaker from closing.
- 12) Provide each automatic reclosing and load measuring function with test facilities that shall check the functioning of all devices.
 - i) Initiate test cycle with a local "test" push-button, which shall be functional only when the circuit breaker removable element is in the "test" position.
 - ii) Circuit breaker shall not close until after completing automatic reclosing and load measuring test when the breaker is in the "connected" position.
- 13) Monitor condition of reclosure device.
- d. Incomplete Sequence (Device 148):
 - 1) This function shall detect the failure of a dc circuit breaker to clear a fault within a predetermined time.
 - 2) This function shall actuate the ac lock-out relay (Device 86) when actuated.
- e. Transfer Trip:
 - 1) Provide two types of transfer trip:
 - i) The first type shall be automatically resettable (Device 85). Automatic resetting shall be controlled by the load measure reclose relay and occurs on di/dt faults.
 - 2) The second type shall require manual resetting (Device 85L). It shall trip the dc lockout relay (Device 186H) in both the originating and receiving substations, and is required for dc instantaneous over-current, frame faults, rail-to-earth potential faults, incomplete sequence faults, and emergency shutdowns. Configure communication interface devices between substations for transfer trip function over a communications network. Provide communication function blocks or other programming required for relays and IEDs to establish relay-to-relay communication between substations.
 - 3) Monitor the condition of the communications network continuously.
 - 4) Generate an alarm if a fault condition is detected.

- 5) Tripping of a dc breaker shall initiate tripping of the remote active breaker feeding the same section.
 - 6) Transfer trip shall be integral to protection relays. Communication for transfer trip must be configured using VLAN.
2. Reverse Current:
 - a. Provide reverse current detection (Device 32).
 - b. The protection shall detect current flow from the distribution bus into the rectifier unit and trip and lock out the dc feeder breakers and ac circuit breaker.
 - c. The trip level shall be initially set to 15 percent of the rated current or as approved by Engineer.
 3. High Resistance Frame Fault:
 - a. Insulate dc switchgear enclosure from ground.
 - b. Single-point ground enclosure through a separate high resistance ground IED device 64HS (hot structure) and 64GS (grounded structure).
 - 1) Connect IED with insulated 4/0 AWG copper conductor directly to substation ground mat.
 - 2) The 64HS and GS relay shall be the only ground path to the enclosure.
 - 3) The occurrence of any other ground path must be detected and alarmed.

2.9 INSTRUMENTS AND METERS

- A. Instruments and meters shall be integrated into intelligent electronic devices (IEDs).
 1. Voltmeters and ammeters shall be rated for use with the corresponding transducers.
 2. Scales shall be of a suitable range, equal to the associated potential or current transformer primary rating.
- B. Provide instrument and metering IEDs with capability of communicating with SAS as specified in Section 34 21 31, Substation Automation System (SAS).
- C. Instruments and metering devices for measuring dc values shall receive their inputs from isolation converters that shall be provided within the bus compartment of the switchgear.
 1. Provide auxiliary devices required for operation of the converters.
 2. Provide suitable isolation and insulation in order to ensure safe operation in contact with personnel.
 3. MSF Switchgear: Design to be maintainable from the front.

2.10 FACTORY ASSEMBLY

- A. Completely insulate dc switchgear enclosure and rectifier from ground and from the traction power transformer and the ac switchgear.
 1. Insulate and isolate dc switchgear and rectifier from the floor using an epoxy floor covering in accordance with Section 09 67 25, Dielectric Epoxy Flooring.

2. Insulate and isolate dc switchgear and rectifier from the transformer using electrical laminate in accordance with Section 34 21 05, Common Work Results for Traction Electrification System (TES).
3. Insulate walls using electrical laminate in accordance with Section 34 21 05, Common Work Results for Traction Electrification System (TES), and as shown on Contract Drawings.

2.11 SOURCE QUALITY CONTROL

A. Factory Design Tests:

1. Dc Switchgear:
 - a. Perform on the dc switchgear assembly.
 - b. Perform the "design tests" specified in IEEE C37.20.1.
 - c. Insert and remove circuit breaker elements into connected position 200 times from disconnect position.
 - d. Drawout mechanism shall function properly showing no signs of wear.
 - e. Inspect main and auxiliary contacts for damage and weakness.
 - f. Contacts shall sustain no physical damage or wear. No wear is permissible.
 - g. Contacts shall make full contact with mating member as determined by Engineer.
2. Dc Circuit Breaker:
 - a. Perform in accordance with design tests in IEEE C37.14.
 - b. Follow schedule of design tests defined in IEEE C37.14.
3. Positive and Negative Disconnect Switches: Test in accordance with design tests specified in IEEE C37.41.
4. Dc Protection Relays and Control Devices:
 - a. Perform in accordance with design tests in IEEE C37.90.
 - b. Frame Fault Relay (Device 64 HS and GS): Following design tests are required.
 - 1) Continuous and maximum short circuit ratings: Demonstrate by test.
 - 2) Response time and maximum trip time: Demonstrate by test.
 - 3) Maximum trip time for this device shall not exceed 50 ms.

B. Factory Production Tests:

1. Dc Switchgear:
 - a. Perform in accordance with IEEE C37.20.1:
 - 1) Dielectric tests.
 - 2) Mechanical operation tests.
 - 3) Electrical operation and control wiring continuity, except that control wiring continuity shall be verified by actual electrical operation of control devices.
2. Dc Circuit Breaker:

- a. Perform on each dc circuit breaker in accordance with IEEE C37.14 prior to mounting inside dc switchgear:
 - 1) Calibration test.
 - 2) Control, secondary wiring and device check test.
 - 3) Dielectric withstand voltage test.
 - 4) No-load operation test.
- b. Perform on each dc circuit breaker after mounting in switchgear:
 - 1) Operation test.
 - 2) Position test: Disconnected, test, and connected positions.
 - 3) Alignment test of primary and secondary contacts.
 - 4) Interlocking test for all positions.
- 3. Positive and Negative Disconnect Switches:
 - a. Perform for each disconnect switch in compliance with production tests in IEEE C37.41.
 - b. Perform standard production tests on all switches to check the quality and uniformity of workmanship and materials used, including the following:
 - 1) Check for gaps, using a feeler gage (or other approved method) at each contact and assembly point. Gaps are grounds for rejection.
 - 2) Test operation of all components.
 - 3) Perform power frequency dielectric withstand test.
 - 4) Test electric resistance of current path.
- 4. Dc Protection Relays, Control Devices and Meters: Perform in accordance with production tests in IEEE C37.90.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Insulate dc switchgear in built-in-place substation as required in Part 2, above, in the article titled "Factory Assembly."

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification
SECTION 34 21 23
TRANSFORMER-RECTIFIER UNIT

PART 1 - GENERAL

1.1 SUMMARY

- A. Traction power transformers (TPT) and rectifiers, which are referred to in this Section as the "Transformer-Rectifier Unit," for the traction power substations.

1.2 RELATED SECTIONS

- A. Section 05 05 00 – Common Work Results for Metals
- B. Section 09 67 25 – Dielectric Epoxy Flooring
- C. Section 26 05 19 – Low-Voltage Conductors and Cable
- D. Section 26 24 13 – Switchboards
- E. Section 26 50 00 – Lighting
- F. Section 34 21 05 – Common Work Results for Traction Electrification System (TES)
- G. Section 34 21 31 – Substation Automation System (SAS)
- H. Section 34 21 80 – TES Spare Parts and Special Tools
- I. Section 34 21 90 – Traction Electrification System Testing

1.3 REFERENCE STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents:
- B. National Electrical Manufacturers Association (NEMA)
 - 1. NEMA 260, Safety Labels for Padmounted Switchgear and Transformers Sited In Public Areas
 - 2. NEMA TR 1, Transformers, Regulators and Reactors
 - 3. NEMA SG 6, Power Switching Equipment
- C. American Society for Testing and Materials (ASTM)
 - 1. ASTM D116, Vitrified Ceramic Materials for Electrical Applications
- D. Institute of Electrical & Electronics Engineers (IEEE)
 - 1. IEEE 519, Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
 - 2. IEEE 1653.2, Standard for Uncontrolled Traction Power Rectifiers for Substation Applications Up to 1500 Vdc Nominal Output
 - 3. IEEE C37.20.3, Standard for Metal-Enclosed Interrupter Switchgear

4. IEEE C57.12.01, General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid-Cast and/or Resin Encapsulated Windings
5. IEEE C57.12.91, Standard Test Code for Dry-Type Distribution and Power Transformers

1.4 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Product Data:
 1. Manufacturer's product descriptions and catalog data.
 2. Bus and bus insulators.
 3. Core steel.
 4. Transformer winding insulation system.
 5. Interphase transformer
 6. Relays, protective devices, control switches, over temperature devices and failed diode indication device.
 7. Information concerning design and application ratings.
 8. Information concerning service, performance and reliability.
 9. Documents confirming the substation system rating.
- C. Spare Parts and Special Tools:
 1. Submit a list of spare parts to be provided under this Section.
 2. Submit at the same time as product data.
 3. Provide part numbers for each part, including a detailed break down of each spare part assembly and set, as defined in Section 34 21 80, TES Spare Parts and Special Tools.
 4. Submit a list of special tools to be provided under this Section, as defined in Section 34 21 80, TES Spare Parts and Special Tools.
- D. Shop Drawings:
 1. Manufacturer's arrangement and outline dimensions for each item of transformer-rectifier unit.
 2. Detail drawings for each item of transformer-rectifier unit, including interphase transformer, TPT insulation system details, and surge arrester arrangement, mounting, and protective shield.
 3. Transformer and power rectifier circuit diagrams.
 4. Wiring, schematic, and connection diagrams.
 5. Transformer nameplate drawing with nameplate details.
 6. Rectifier nameplate drawing.
 7. Transformer outline drawing showing dimensions, front, back and side elevations of enclosure, overall dimensions, lifting lugs, and transformer data, including weight, impedance, and primary and secondary BIL.

8. Transformer primary and secondary busing arrangements showing bus construction details and bill of materials.
 9. Transformer temperature monitor/protection device schematic and wiring diagram including the location of the temperature sensor.
 10. Rectifier monitoring and protection schematic and wiring diagram.
 11. Transformer tap changer arrangement details.
 12. Transformer enclosure and door latch details.
 13. Rectifier enclosure and door latch details.
- E. Calculations:
1. Transformer design calculations, including hottest spot temperature rise in accordance with IEEE C57.12.01.
 2. Transformer calculation of winding temperature during a short circuit in accordance with IEEE C57.12.01.
 3. Bus sizing calculations.
 4. Transformer design optimization calculations.
 5. Proof the transformer rectifier design and construction conforms to IEEE 519.
- F. Submit the following upon completion of transformer manufacture:
1. Measured present worth of transformer energy losses, including the following:
 - a. Table 1, with actual measured losses from the transformer.
 - b. Table 2 calculation, using the new value from Table 1.
 2. Comparison of calculated and measured present worth of transformer energy losses, as described in the Article below titled "Transformer Design Optimization."
- G. Submit test procedures that comply with Section 34 21 90, Traction Electrification System Testing.
1. Design Tests.
 2. Production Tests.
- H. Submit test reports that comply with Section 34 21 90, Traction Electrification System Testing.
1. Design Tests: Provide design test reports for each type of transformer-rectifier unit within 30 Days after completion of testing.
 2. Production Tests: Provide production test reports for each transformer-rectifier unit within 30 Days after completion of testing.
- I. Operations and Maintenance Data:
1. Submit manufacturer's operating and maintenance instructions on products specified in this Section, including the following:
 - a. Submit manufacturer's operating and maintenance instructions, parts list, illustrations and diagram for components for products specified in this Section.
 - b. Submit immediately after approval of product data.

- c. Wiring diagram.
 - d. Diagram showing recommended safety grounding during maintenance.
2. Submit immediately after approval of product data.

1.5 SPARE PARTS

- A. Provide spare parts in accordance with Section 34 21 80, TES Spare Parts and Special Tools.
- B. List below applies to items in this Specification Section.
 - 1. Traction power transformer: Provide 1 spare.
 - 2. Transformer temperature monitor complete with temperature sensors: Provide 1 spare assembly.
 - 3. Rectifier diodes: Provide 7 spare.
 - 4. Rectifier diode protection fuses: Provide 7 spare.
 - 5. Rectifier over-temperature: Provide 7 spare assemblies.
 - 6. Interphase transformer: Provide 1 spare.

1.6 QUALITY ASSURANCE

- A. Traction power transformer (TPT) shall be UL labeled or shall be furnished with a Field Evaluation label in accordance with Section 34 21 05, Common Work Results for Traction Electrification System (TES).
- B. Rectifier shall be UL labeled or shall be furnished with a Field Evaluation label in accordance with Section 34 21 05, Common Work Results for Traction Electrification System (TES).

1.7 WARRANTY

- A. Provide an extended warranty of 5 years for traction power transformers.

PART 2 - PRODUCTS

2.1 TRANSFORMER-RECTIFIER UNIT - GENERAL REQUIREMENTS

- A. Transformer-rectifier unit shall be manufactured in accordance with the referenced standards.
- B. Transformer-rectifier unit consists of a separate traction power transformer and a rectifier, as shown on Contract Drawings.
 - 1. Provide each unit complete with auxiliaries, controls, wireways, interconnecting ac and dc buses, enclosures and necessary hardware, wiring and devices from the high voltage side of the transformer to the dc bus connections to the dc switchgear and negative enclosure.
 - 2. Except as otherwise specified, the transformer-rectifier shall conform to IEEE C57.12.01, C57.12.91, 519, and 1653.2, and NEMA SG 6 and TR 1.
- C. Dc output of the transformer-rectifier unit shall feed the metal enclosed dc switchgear that controls and protects the power supply to the Overhead Contact System (OCS).
- D. Enclosures for Transformer and Rectifier
 - 1. Construct from sheet steel, 11 gage minimum, properly reinforced against distortion by suitable flanges and stiffening members.

2. Doors:
 - a. Minimum 11 gage sheet steel.
 - b. Doors 36 inches or wider shall include vertical stiffeners, minimum 3 stiffeners for a 36-inch door, with one additional stiffener for each additional 12 inches of door width.
3. Finish: Powder coat in accordance with 05 05 00, Common Work Results for Metals.
4. Color: In accordance with Section 05 05 00, Common Work Results for Metals.
- E. Design Loading Condition: Transformer-rectifier units shall meet the duty cycle specified in IEEE 1653.2 for light traction service.
- F. Efficiency: Overall efficiency of each transformer-rectifier assembly shall be greater than 98 percent at its continuous rating.
- G. Power Factor: Displacement power factor of each transformer-rectifier assembly shall be 0.95 or greater from 25 percent to full load at rated ac voltage.
- H. Voltage Regulation:
 1. Minimum 4-1/2 percent between 1 percent and 200 percent load with the nominal ac voltage maintained at the transformer primary and the transformer set at the rated voltage tap.
 2. Engineer may allow minor variations in regulation based upon submitted design curve.
- I. Dummy Load:
 1. Limit the no-load voltage to the value specified.
 2. Provide a bleeder resistance dummy load, if required, to prevent excessive voltage rise at no-load.
- J. Provide protection against transient surge voltages on the dc side of the rectifier. If fuses are used in suppression networks, they shall be monitored by visual indicators and equipped with indication devices wired to local Annunciator.
- K. Short Circuit Ratings:
 1. Design transformer, including terminal connections and buswork, to withstand a full short circuit with shorted low-voltage terminals and rated voltage on the high-voltage terminals, in accordance with IEEE C57.12.01. The duration of the short-circuit current shall be minimum 1 second.
 2. Design all parts of the rectifier unit, including the terminal connections and buswork, to withstand a maximum dc fault on the dc positive bus, without damage, for the period required for the back-up protection to operate and open the ac circuit breaker.

2.2 TRANSFORMER-RECTIFIER UNIT RATINGS AND CONFIGURATION

- A. Mainline transformer-rectifier units:
 1. Rating:
 - a. Dual-rated 600/750 Vdc, 350 kW measured at output terminals.
 - b. Default output: 600 Vdc.
 2. Configuration: 12-pulse, double-way, in accordance with IEEE 1653.2, Circuit 31.

3. Convert 480 V, 60 Hz ac, three-phase, three-conductor primary power to 600/750 Vdc at 100 percent of full load.
 4. Ac power source: 480 Vac switchboard; see Section 26 24 13, Switchboards.
- B. MSF transformer-rectifier unit:
1. Rating:
 - a. Dual-rated 600/750 Vdc, 150 kW measured at output terminals.
 - b. Default output: 600 Vdc.
 2. Configuration: 6-pulse, in accordance with IEEE 1653.2.
 3. Convert 480 V, 60 Hz ac, three-phase, three-conductor primary power to 600/750 Vdc at 100 percent of full load.
 4. Ac power source: 480 Vac switchboard; see Section 26 24 13, Switchboards.

2.3 PROTECTIVE DEVICES AND RELAYS FOR TRANSFORMER-RECTIFIER UNIT

- A. Coordinate protection to prevent false tripping or malfunction.
- B. Supply an insulating dust cover for each internally-mounted device or the chamber that accommodates these devices.
- C. Compartment: Mount control devices, relays and protective devices within the rectifier and transformer enclosure within a separate barriered compartment in compliance with IEEE C37.20.3.
1. Devices shall be readily accessible without disassembling interior portions of the rectifier assembly.
 2. Control wiring shall be contained within the cubicle.
 3. Control wiring shall be barriered from and not intermixed with 600/750 Vdc power wiring.
 4. No 600/750 Vdc devices shall be mounted in control compartment.
 5. Locate devices such that heat from other equipment does not affect operation.
- D. Control Power:
1. Power supply for protective devices and relays shall use 125 Vdc dc auxiliary power system.
- E. Transformer Temperature Monitor:
1. Transformer Temperature Monitor (TTM): Device 49:
 - a. Shall be manufactured for the purpose.
 - b. Shall have a service proven history.
 2. The TTM shall incorporate a hot spot winding temperature indicator:
 - a. Location shall be that of the highest temperature reading obtained during the System Design testing.

3. TTM shall be provided with two-step, electrically independent contacts that close on rising temperatures for alarm (first step) and tripping (second step).
 - a. First stage of TTM temperature supervision, 49T1, shall initiate an alarm on the TTM and the SAS. Refer to Section 34 21 31, Substation Automation System (SAS).
 - 1) The first stage shall initially be set at the temperature reached during the 2-hour heat run at 150 percent rated output, and annunciate when this temperature is reached.
 - b. Second stage, 49T2, shall initiate an alarm on the TTM and the SAS and shall also trip and lock out the main ac breaker and open the main dc circuit breaker.
 - c. Set Points:
 - 1) Temperature set points, T1 and T2, shall be field adjustable.
 - 2) Set points shall be factory-preset value when transformer is provided, as recommended by the manufacturer and approved by Engineer.
4. Display temperature continuously on a digital display mounted on the surface of transformer panel.
 - a. Accuracy: Within 1.5 percent of the full-scale reading.
 - b. Scale: Degrees Celsius.
 - c. Peak Temperature:
 - 1) Peak temperature shall be displayed when requested by the activation of a front panel mounted pushbutton.
 - 2) Peak temperature shall be resettable via a separate front panel mounted pushbutton.
 - 3) TTM shall store the peak temperature reached by the traction power transformer.
5. Enclosure: NEMA 1 enclosure for low voltage terminals.
 - a. Cover: Hinged- or screw-type.
6. Terminal strips: Provide covers and mount on back panel.
7. Barriers: Provide where necessary to separate conductors with different voltage insulation ratings, such as thermocouple wiring and 125 Vdc control wiring.
8. Mounting: Securely mount enclosure to the transformer frame.
 - a. Mount in a location readily accessible from the front as indicated, but not to restrict access to the transformer coils for maintenance.
 - b. Do not mount the enclosure in removable panels.
9. Control Wiring:
 - a. Control wiring shall be 600 V switchboard wire. See Section 26 05 19, Low-Voltage Conductors and Cable, for switchboard wire requirements.
 - b. Size: Minimum 14 AWG, except for temperature sensor internal wiring.
10. Contacts: Electrically separate and suitable for operation at 125 Vdc.

- F. Provide the following protective devices for the rectifier. Contacts on these devices shall be electrically separated:
1. Rectifier over-temperature (Device 26):
 - a. Over temperature device shall be factory set, two stages (26R1 and 26R2).
 - b. Shall detect first an abnormal rise in diode heat sink or diode temperature and initiate local and remote annunciation.
 - c. Set-point for the alarm shall be set during the factory systems test to the level recorded during the two hour 150 percent heat run.
 - d. An additional rise in heat sink temperature will trip and lock out the ac main breaker, open the main positive circuit breaker and shall alarm on the SAS. Refer to Section 34 21 31, Substation Automation System (SAS).
 - e. Devices shall be isolated from the bus voltage.
 2. Frame fault protection for the rectifier: Provide high resistance frame fault protection for the rectifier cubicles.
 3. Provide failed diode indications 98R1 and 98R2.
 4. Refer to Contract Drawings for additional protective devices.

2.4 RECTIFIER

- A. General:
1. Provide rectifier assembly as an integral part of the dc switchgear.
 2. Rectifier assembly shall be constructed in accordance with IEEE C37.20.3, except as modified in this Section.
 3. Rectifier shall include silicon diodes, internal buses, terminals for connection to external power and control wiring or buses, shunts, base or bleeder load resistors, protective devices, control wiring, terminal blocks, compartments, cubicles, and all other necessary accessories.
 4. All rectifier assemblies shall be identical, except for necessary differences in the MSF rectifier.
- B. Rating and configuration:
1. IEEE 1653.2 light traction service.
 2. Dc Insulation: 1200-Volt Class.
 3. Mainline rectifiers:
 - a. Dual-rated 600/750 Vdc, 350 kW, with natural convection air cooling.
 - b. Continuous current rating at 100 percent: 583 A.
 - c. Twelve-phase, double-way, 12-pulse rectification.
 4. MSF rectifier:
 - a. Dual-rated 600/750 Vdc, 150 kW, with natural convection air cooling.
 - b. Continuous current rating at 100 percent: 250 A.
 - c. Six-phase, double-way, 6-pulse rectification.

5. Cooling fans:

- a. Provide fans for forced air cooling to increase continuous current rating by 33 percent.
- b. Rectifier shall not suffer loss of life when operated at the IEEE 1653.2 light traction service overload.

C. Enclosure:

1. Mount rectifier assembly in a metal fully-enclosed switchgear section or compartment.
2. The switchgear section shall be indoor, self-ventilated, metal enclosed structure with barriers, compartments, hinged doors as required by IEEE C37.20.3, except as modified in this Section.
3. Assemble enclosure with a rigid self-supporting structural steel framework.
 - a. Structural members shall be of sufficient strength to support the buswork under short circuit conditions.
 - b. Principal structural members shall be electrically welded or bolted together.
 - c. Provide lifting eyes for lifting the rectifier unit from the top.
 - d. The completed package shall be capable of being skidded or rolled any direction.
 - e. Provide jacking lugs at each base corner.
4. Doors:
 - a. Provide convenient access doors on the front and rear of the section for normal maintenance and inspection.
 - b. Latches: Equip each door with a heavy duty latch to hold the door fully and securely closed.
 - c. Hinges: Stainless steel heavy-duty type.
 - d. Door Stops:
 - 1) Provide heavy duty door stops to hold the door in the open position.
 - 2) Not easily bent if an attempt is made to close door without releasing door stop.
 - e. Window: Provide an ample sized, wired glass, gasketed observation window on each door to observe diode blown fuse indicators.
 - f. Install front-mounted indicating and control devices without damaging the exposed finished surfaces.
5. Lights: Provide inside equipment enclosures, as specified in Section 26 50 00, Lighting.

D. Bus and Connections:

1. Rectifier buses shall be made of rigid, high conductivity, electrical grade copper.
2. Buses shall be suitably braced between each other and to the enclosure with high-strength, non-tracking porcelain or fiberglass insulators.
3. Buses shall be braced to safely withstand the available short-circuit current without damage to the bus or the rectifier.

4. Where aluminum heat sinks are bonded to a copper bus, coat connection with oxide inhibitor to prevent bimetallic corrosion.
5. Bus connections shall be bolted using a minimum of four bolts per joint.
 - a. Wherever bolted together, the mating surfaces of copper buses shall be silver-plated.
 - b. Bolted connections shall be made with Belleville washers.
6. Buses shall extend through the compartment walls to rear bus compartment and connected to the dc switchgear.
7. Rectifier section shall be designed as an integral part of the dc switchgear line up and shall be insulated from the ac and dc switchgear, substation grounds, or other enclosures.
8. Metal barriers, electrically bonded to the frame, shall be provided between dc positive and negative buses and terminal connections within the rectifier.

E. Dc surge arrester:

1. Rectifier unit shall be equipped with dc surge arresters.
2. The arresters shall limit the reverse voltage across rectifier silicon diodes to a value less than 75 percent of the peak-reverse-voltage rating of the diode by limiting the rise of the transient on the positive to negative bus.
3. Ensure that arresters will fail in a safe manner without damage to equipment and will self extinguish. Install in separate enclosure if necessary.

F. Silicon Diodes:

1. Silicon diodes shall be hermetically sealed and mounted on adequate heat sinks.
2. Diodes shall be rated and tested in accordance with IEEE 1653.2 for light traction service.
3. Rectifier shall be able to withstand a bolted fault on the dc switchgear bus without exceeding the safe diode junction temperature on the active diode for the time it takes the ac breaker to clear the fault.
4. Each diode shall be capable of withstanding, at its maximum operating temperature during blocking periods, repetitive voltages having a value 250 percent of its working peak reverse voltage without a permanent change in diode characteristics.
5. Each individual diode shall have a peak inverse voltage rating equal to at least 266 percent of the applied peak inverse voltage at no load.
6. Parallel stacks of diodes, when used, shall be electrically and geometrically similar and as symmetrical as practical to help balance the normal and surge electrical characteristics of each.
7. Design rectifier to maintain current balance between parallel-connected diodes, if used, in each phase.
 - a. The current for each diode of a parallel-connected stack shall not differ from its proportionate share of the total current by more than plus or minus 10 percent, between 50 percent and 150 percent of the rated capacity.
 - b. Current balancing shall not be achieved by use of selectively matched diodes.

G. Fuses:

1. Provide one current limiting fuse in series with each phase.
 - a. Each fuse shall have adequate interrupting capacity
 - b. Provide a visual fuse failure indication.
 - c. Fuse failure indication shall be visible from outside rectifier through observation window.
2. Size fuses to the diode current rating. Diodes shall not open or fail on an external dc fault or rated overload condition.
 - a. Only the fuse connected to a failed (shorted) diode shall open.
 - b. No other rectifier diodes or fuses shall fail or be damaged when one diode fails.
3. Fuses: 750 V minimum, indicating type, affixed with micro switches for Device 98.

H. Diode Failure:

1. Diode failure 1 (98R1): If one diode fails, or if one entire leg fails, send alarm to SAS.
2. Diode failure 2 (98R2): If one leg has failed, and a second leg fails, trip the ac lockout relay (Device 86).

I. Special Tools: Provide special tools to remove or install the diodes and/or diode fuses and/or hardware with each substation rectifier.

J. Internal Wiring: 2 kV switchboard wire, per Section 26 05 19, Low-Voltage Conductors and Cable.

K. Heating and Cooling System:

1. Auxiliary heating will be by a thermostatically-controlled space heater within the Substation. Heaters mounted within the rectifier enclosure are not necessary.
2. Rectifier shall be natural convection air-cooled.
 - a. Circulation of ambient air shall do all necessary cooling at the IEEE 1653.2 light traction service loading specified.
 - b. Cooling ducts shall not be used.
3. All rectifiers shall be equipped with fans and thermostats for future forced air cooling.

L. Maintenance: Heat transfer surfaces and characteristics shall be designed for easy cleaning and to minimize accumulations of dust and other contaminants expected in the operating environment.

M. In accordance with this Specification, voltages other than 125 Vdc control power are not permitted within the enclosure unless a specific requirement is stated in this Contract.

N. Nameplate:

1. Provided each rectifier with a corrosion resistant metal nameplate containing the following information at a minimum:
 - a. Name of Manufacturer.
 - b. Descriptive Name.
 - c. Type Designation.

- d. Serial Number(s).
- e. Output Rated Power.
- f. Output Rated Voltage.
- g. Output Rated Current.
- h. Overload Currents - Magnitude and Duration.
- i. Weight.
- j. Schematic Diagram Number.

2.5 TRACTION POWER TRANSFORMER

- A. Provide dry-type traction power transformer of VPI (Vacuum Pressure Impregnation).
- B. Ratings and Configuration:
 - 1. Ventilated, self-cooled Class AA/FA.
 - 2. Transformer capacity shall be as required to achieve the specified transformer-rectifier unit rating.
 - 3. IEEE 1653.2 light traction service duty cycle.
 - 4. Transformer shall not suffer loss of life when operated at the specified duty cycle overload.
 - 5. Insulation Class: 220 degrees C class.
 - 6. Temperature Rise: Limit winding hottest-spot temperature rise and average winding temperature rise to the values given in IEEE C57.12.01 for the specified insulation class.
 - 7. Cooling fans:
 - a. Provide fans for forced air cooling, controlled by transformer temperature monitor.
 - b. Fans shall increase the overall rating of traction power transformer by 33 percent of its rated output current without exceeding specified temperature rise.
 - 8. Select the transformer impedance to provide the rectifier output voltage specified.
- C. Windings:
 - 1. Material: Copper.
 - 2. Windings shall not absorb moisture and shall be suitable for both storage and operation in adverse environments, including prolonged storage in 100 percent humidity at temperature from minus 30 degrees C to 40 degrees C.
 - 3. Primary windings mainline and Yard:
 - a. Delta-connected.
 - b. 30 kV BIL.
 - 4. Secondary windings mainline and Yard:
 - a. Connected for 12-pulse rectification.
 - b. 30 kV BIL

5. Primary windings MSF:
 - a. Delta connected.
 - b. 30 kV BIL
6. Secondary windings MSF:
 - a. Connected for 6-pulse rectification.
 - b. 10 kV BIL.

D. Taps:

1. Provide full-capacity taps on the primary voltage windings to change the nominal output voltage of the transformer-rectifier unit from 600 to 750 Vdc.
2. Provide full capacity taps on primary voltage windings:
 - a. Two above rated voltage in 1.25-percent steps;
 - b. Two below rated voltage in 2.5 percent steps;
 - c. One at rated voltage.
 - d. Taps to the nearest turn are acceptable if the exact percentage cannot be achieved.
3. Tap changing shall be by movable silver plated copper bus links for de-energized tap changing.
4. Taps shall be brought out the side of the transformer, not the top.
5. Insulate jumpers from the transformer taps to the tap changer board and primary bus and keep as short as possible so as not to interfere with access to the coils for maintenance.
6. Tap connections shall be accessible through the front hinged enclosure doors.
7. Identify tap connections so that the tap selected is clearly visible through the observation window.
8. Securely bolt the tap-changing bus links in position.
9. Design of links and connectors shall make it impossible to short out sections of windings, or to select taps outside the prescribed range, by incorrectly connecting the links.

E. Connections:

1. Switchboard: Connect the high-voltage side using electrical grade copper bus with silver plated joints.
2. Rectifier: Connect the low voltage side using electrical grade copper bus with silver plated joints.

F. Supports:

1. Porcelain insulators: ASTM D116.
 - a. Insulators shall be rated for the line-to-line voltage application, free of imperfections.
 - b. Insulators that have been re-touched with paint shall not be used.

2. Securely support bus from transformer frame using porcelain insulators.
 - a. Size bus supports for mechanical strength and ability to withstand a bolted fault without distortion.

G. Bus Bars:

1. Size:
 - a. Minimum 1/4-inch by 2-inch, sized for mechanical strength and ability to withstand a bolted fault without distortion.
 - b. Size bus for a current density of 750 A per square inch, or a maximum temperature of 90 degrees C at a 40 degree C ambient, whichever results in a larger size.
2. Bolted connections: Use a minimum of two silicon bronze bolted connections with Belville washers on high and low voltage ac and dc buses.

H. Conductors within Transformer Enclosure:

1. Conductors not connected to transformer primary or secondary:
 - a. Voltage rating: 600 V.
 - b. Temperature rating: 105 degrees C.
 - c. Protection:
 - 1) Enclose in GRS conduit securely strapped to the transformer frame or base, or to the enclosure if conduit does not obstruct removable panels or doors.
 - 2) If conduit must be secured to both frame or base and enclosure, insert a short section of liquidtight flexible metallic conduit for vibration isolation.
 - 3) Conductors may be unprotected for a maximum of 8 inches at the point of connection.
2. Cable jumpers from the secondary taps on the coil to the bus:
 - a. Sized for maximum loading for IEEE 1653.2 light traction service.
 - b. Temperature rating: 105 degrees C
 - c. Voltage rating: 2 kV.
 - d. Insulation level: 133 percent.

I. Maintainability:

1. Design transformer so that parts that require maintenance are readily accessible from the front and rear.
2. Ensure that bottom and top of coils are readily accessible for cleaning without removing buswork, panels, or obstructions of any kind.

J. Transformer Enclosure and Base:

1. Enclosure:
 - a. Enclose transformer in a rigid, self-supporting and self-contained, electrically welded or bolted, indoor, steel enclosure.

- b. Enclosure shall not rely on transformer frame for support. Avoid attachments to transformer frame.
 - c. Vibration isolation: If enclosure is attached to transformer at any point, provide vibration isolation at attachment points.
- 2. Front door: The entire front of the transformer shall open by padlockable hinged double doors secured by three-point latches.
 - a. Window: Provide an ample sized, wired glass, gasketed observation window in the front hinged doors; position such that the tap connections are readily visible.
- 3. Ventilation louvers: Design for maximum cooling from the bottom to top.
- 4. Rear panels:
 - a. The rear of the transformer shall be accessible by removable panels with stainless steel handles and lifting means.
 - b. Secure panels with 3/8-inch minimum stainless steel vandal-proof machine screws tapped into machined bosses.
- 5. Transformer base:
 - a. Construct from structural steel members suitable for rolling or skidding in any direction.
 - b. Make provisions for pulling along the centerlines perpendicular to each side.
 - c. Provide jacking facilities at each of the four corners of the base to permit insertion of rollers between floor and base.
 - d. Base construction shall firmly secure the core to prevent relative motion of the core during shipment, handling, or seismic shock.
- 6. Transformer frame:
 - a. Provide lifting hooks or eyes on the transformer frame with a safety factor of four to facilitate lifting the unit.
 - b. The structure shall be sufficiently rigid to withstand maximum transformer short circuit currents without deformation.
- 7. Transformer Mounting: Design to minimize vibration by using vibration isolation dampers.
- 8. Lights: Provide inside equipment enclosures, as specified in Section 26 50 00, Lighting.
- 9. Nameplate:
 - a. Provide traction power transformer with a corrosion-resistant metal nameplate marked in accordance with IEEE C57.12.01.
 - b. Securely fasten to the front of the enclosure.
- K. Ac Surge Arrester:
 - 1. Provide ac surge arresters on the traction power transformer primary side.
 - 2. Provide a separate compartment for ac surge arresters within transformer enclosure.
 - 3. Compartment shall be rigid steel, self-supporting and self-contained, electrically welded or bolted.

2.6 TRANSFORMER DESIGN OPTIMIZATION

- A. Optimize the transformer design and select appropriate materials to provide transformers with the lowest possible life cycle cost.
1. Definition of Life Cycle Cost: The sum of the cost of procurement and the cost of energy losses over the equipment's expected life.
 2. Calculate cost of energy losses over the transformer's expected life by:
 - a. First, calculating annual cost of transformer energy losses (see Table 1, below);
 - b. Second, using the calculated annual cost of transformer energy losses to calculate the present worth of transformer energy losses over the 30-year expected life (see Table 2, below).

TABLE 1 – TRANSFORMER ENERGY LOSS SCHEDULE			
Column 1	Column 2	Column 3	Column 4
Transformer Load (as percentage of rated power)	Transformer Energy Losses (at Column 1 Loads) (kW)	Estimated Annual Hours (of operation at given loads) (Hrs)	Annual Transformer Energy Losses (kWh)
0 percent		4380	
20 percent		2190	
60 percent		1314	
100 percent		788	
150 percent		88	
220 percent		0	
300 percent		0	
Total Transformer Annual Energy Losses E_L (kWh)			

- B. Using Table 1 – Transformer Energy Loss Schedule:
1. In Column 2, enter transformer energy losses in kW for each indicated transformer load in Column 1. Include energy losses in the transformer windings, steel core, and busbars, and demand requirements of auxiliary equipment such as cooling fans.
 2. In Column 4 calculate the Transformer Annual Energy Losses in kWh by multiplying the Transformer Energy Losses entered in Column 2 by the Estimated Annual Hours provided in Column 3.
 3. Total the numbers in Column 4 and enter in the box at the bottom of Table 1 for the Transformer Annual Energy Losses, E_L .
 4. Use this number to calculate the Present Worth of Transformer Energy Losses in Table 2.

TABLE 2 – PRESENT WORTH OF TRANSFORMER ENERGY LOSSES		
Equation:	$PW = N \cdot E_L \cdot e \cdot [1/(1+i) + (1+k)/(1+i)^2 + \dots + (1+k)^{n-1}/(1+i)^n]$	
Symbol	Description	Value
PW	Present worth of transformer energy losses (Dollars)	\$
N	Number of transformer units	4 (mainline only)
E _L	Transformer annual energy losses (kWh)	from Table 1
e	Utility energy rate (Dollars/kWh)	0.07
i	Interest rate	0.04 (4 percent)
k	Average energy cost escalation factor	0.04
n	Transformer expected life (years)	30

C. Using Table 2 – Present Worth of Transformer Energy Losses:

1. Calculate the Present Worth of Energy Losses, PW, in dollars over a 30-year period using the equation and values in Table 2.
2. Insert the calculated Present Worth of Transformer Energy Losses into the Request for Proposal Bid List, where indicated.

D. Measured Present Worth of Transformer Energy Losses:

1. After transformer is manufactured, measure the actual losses for the transformer at the load levels specified in Table 1.
2. Update Table 1 with the measured values and recalculate Transformer Annual Energy Losses.
3. Calculate the Present Worth of Transformer Energy Losses using Table 2, with the new value of Transformer Annual Energy Losses based on measured values.

E. Comparison of Calculated and Measured Present Worth of Transformer Energy Losses:

1. Compare the Calculated Present Worth of Transformer Energy Losses (entered on the Price Page) with the Measured Present Worth of Transformer Energy Losses (calculated using measured values of a transformer manufactured for this project).
2. If the Measured Present Worth of Transformer Energy Losses exceeds the Calculated Present Worth of Transformer Energy Losses, the Engineer will issue a unilateral deductive Change Order to deduct the dollar value of the difference between the two.
3. If the Measured Present Worth of Transformer Energy Losses is equal to or less than the Calculated Present Worth of Transformer Energy Losses, no action will be taken.

2.7 INTERPHASE TRANSFORMER

- A. Design interphase transformer in coordination with transformer-rectifier unit to meet the specified voltage regulation and maximize efficiency, under City of El Paso service conditions.
- B. Design, submit product data and shop drawings, and test in accordance with IEEE 1653.2.

2.8 FACTORY ASSEMBLY

- A. Completely insulate rectifier from ground and from the traction power transformer and the ac switchgear.
 - 1. Insulate and isolate rectifier from the floor using an epoxy floor covering in accordance with Section 09 67 25, Dielectric Epoxy Flooring.
 - 2. Insulate and isolate rectifier from the transformer using electrical laminate in accordance with Section 34 21 05, Common Work Results for Traction Electrification System (TES).

2.9 SOURCE QUALITY CONTROL

- A. Factory Design Tests:
 - 1. Transformer-Rectifier Unit Test:
 - a. General Requirements:
 - 1) Existing test reports will not be accepted in lieu of this test.
 - 2) Transformer-rectifier unit shall be tested as a complete assembly including interconnecting bus and enclosures.
 - b. Rated current test:
 - 1) Perform in accordance with IEEE 1653.2.
 - 2) Thermocouple locations shall be indicated in test procedure and approved by the Engineer.
 - 3) Transformer temperature rise determined by any of the thermocouples shall not exceed specified values.
 - 4) Verify efficiency, voltage regulation, and power factor at loads shown in IEEE 1653.2 for Light Traction Service.
 - c. Audible sound level test:
 - 1) Perform audible sound level tests in accordance with IEEE C57.12.91 except apply 3-foot distance.
 - 2) Maximum sound level shall not exceed 60 dBA at 100 percent load measured 3 feet away from assembly.
 - 3) For 12-pulse Circuit 31 rectifier transformers, include interphase transformer in transformer-rectifier assembly.
 - 4) Measure sound level with rectifier-transformer in its enclosure with all panels bolted closed.
 - 2. Rectifier:
 - a. Dielectric tests: In accordance with IEEE 1653.2.
 - b. Rated voltage test: Subject rectifier to 110 percent of ac rated voltage for 5 minutes with the dc circuit open.
 - c. Current unbalance test:
 - 1) In accordance with IEEE 1653.2.
 - 2) Test may be performed during the design test for transformer-rectifier unit.

- d. Loss measurement test: Comply with IEEE 1653.2.
- e. Rated current test:
 - 1) At reduced voltage.
 - 2) After temperature stabilization at rated load.
 - 3) Include the overloads outlined in IEEE 1653.2.
 - 4) Perform with one diode removed from each phase arm. Engineer to select diodes to be removed for test.
 - 5) Shall demonstrate that the maximum safe junction temperature for each diode is not exceeded.
 - 6) Verify efficiency, voltage regulation, and power factor at loads shown in IEEE 1653.2 for Light Traction Service.

3. Traction Power Transformer:

- a. Resistance measurements: Take in accordance with IEEE C57.12.91 except that they shall be taken for all tap settings.
- b. Impedance and load loss: Perform tests in accordance with IEEE C57.18.10 except perform on all windings on all tap settings.
- c. Commutating reactance: Calculate from load loss tests in accordance with IEEE C57.18.10.
- d. Impulse test:
 - 1) Perform in accordance with IEEE C57.12.91.
 - 2) Perform after completion of short circuit tests.
- e. Temperature rise tests: Perform in accordance with IEEE C57.12.91 for light traction service.
- f. Partial discharge test: Perform after completion of all other tests.
- g. Short circuit test:
 - 1) Conduct at a certified laboratory.
 - 2) Power supply shall be minimum 10 MVA.
 - 3) Perform in accordance with IEEE C57.12.91
- h. Engineer shall be the sole judge of the serviceability of transformer after completion of design testing.

B. Factory Production Tests:

- 1. Rectifier:
 - a. Dielectric tests: Perform in accordance with IEEE 1653.2.
 - b. Continuity tests: Perform for all cables and buses.
 - c. Rated voltage test: Perform in accordance with IEEE 1653.2.
- 2. Traction Power Transformer:

- a. Dielectric tests: Perform in accordance with IEEE C57.12.91.
- b. Applied-voltage test: Perform in accordance with IEEE C57.12.91.
- c. Induced-voltage tests: Perform in accordance with IEEE C57.12.91.
- d. Resistance measurements: Take for all windings on all taps.
- e. Ratio tests: Perform on the rated voltage connections and on all taps in accordance with IEEE C57.12.91.
- f. Polarity and phase relation tests: Perform in accordance with IEEE C57.12.91.
- g. No-load losses and excitation current: Determine in accordance with IEEE C57.12.91.
- h. Partial discharge test:
 - 1) Subject transformer to an induced voltage of 1.5 times the rated voltage at a frequency between 100 and 400 Hz.
 - 2) Partial discharge extinction level shall be reached at an induced voltage of not less than 1.2 times the rated line-to-line voltage.
 - 3) Partial discharge extinction level will be defined as the point when the reading at 1.9 MHz is less than 10 microvolts or 13 picocoulombs.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Insulate rectifier in built-in-place substation as required in Part 2, above, in the article titled "Factory Assembly."

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification
SECTION 34 21 25
TPSS DC CONTROL POWER

PART 1 - GENERAL

1.1 SUMMARY

- A. Battery charger/eliminator and batteries.
- B. Enclosed low-voltage switches and fuses.
- C. Dc distribution panelboard.
- D. Dc control circuit overcurrent protection.
- E. 24 Vdc power supply.

1.2 RELATED SECTIONS

- A. Section 26 24 16 – Low-Voltage Panelboards
- B. Section 34 21 05 – Common Work Results for Traction Electrification System (TES)
- C. Section 34 21 31 – Substation Automation System (SAS)
- D. Section 34 21 80 – TES Spare Parts and Special Tools
- E. Section 34 21 90 – Traction Electrification System Testing

1.3 REFERENCE STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents:
- B. Institute of Electrical and Electronics Engineers (IEEE)
 - 1. IEEE 1115, Recommended Practice for Sizing Nickel-Cadmium Batteries for Stationary Applications
- C. National Electrical Manufacturers Association (NEMA)
 - 1. NEMA FU 1, Low Voltage Cartridge Fuses
 - 2. NEMA KS 1, Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
 - 3. NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum)
 - 4. NEMA PE 5, Utility Type Battery Chargers

1.4 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Product Data:
 - 1. Submit manufacturers' product data for specified equipment and materials.
- C. Spare Parts and Special Tools:
 - 1. Submit a list of spare parts to be provided under this Section.

2. Submit at the same time as product data.
3. Provide part numbers for each part, including a detailed break down of each spare part assembly and set, as defined in Section 34 21 80, TES Spare Parts and Special Tools.
4. Submit a list of special tools to be provided under this Section. List requirements are defined in Section 34 21 80, TES Spare Parts and Special Tools and required special tools are described below in Part 2.

D. Calculations:

1. Battery capacity calculations, including load calculations.

E. Testing:

1. Submit test procedures that meet the requirements of Section 34 21 90, Traction Electrification System Testing for the following:
 - a. Factory Design Tests.
2. Submit test reports that meet the requirements of Section 34 21 90, Traction Electrification System Testing for the following:
 - a. Factory Design Tests.

F. Operations and Maintenance Data:

1. Submit manufacturer's operating and maintenance instructions on products specified in this Section, including the following:
 - a. Submittal information identified above.
 - b. Manufacturer's operating and maintenance instructions, parts list, illustrations and diagram for components.
2. Submit immediately after approval of product data.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Spare Parts:

1. Deliver spare parts in accordance with Section 34 21 80, TES Spare Parts and Special Tools.
2. Furnish the following items specified in this Section:
 - a. Battery cells: Provide 4 spares of each type.
 - b. Battery charger/eliminator: Provide 1 spare.
 - c. Mini circuit breakers: Provide 2 spare sets.
 - d. 24 Vdc power supply: Provide 2 spares.
3. Special Tools and Accessories: Submit product data and provide as specified in Part 2, below.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Ship batteries separate from substation.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Batteries and associated charger/eliminators shall operate in parallel, with the charger charging the battery while supplying the continuous connected loads.
- B. Batteries shall supply peak short time current demands and, when the ac supply to the charger is interrupted, supply the entire connected load.
- C. Batteries and charger/eliminators shall be rated for operation within the temperature range specified in Section 34 21 05, Common Work Results for Traction Electrification System (TES) and shall be capable of operation up to 100 degrees F.
- D. After a continuous 10 hours of battery charger outage, trip and lockout the high-voltage ac circuit breaker, via the 86H relay and trip and lockout the dc circuit breakers via the 186H relays.

2.2 BATTERY CHARGER/ELIMINATOR

- A. Charger/eliminators: Solid-state, constant voltage, automatic, fully regulated, with output voltage temperature compensation, silicon controlled rectifier, convection cooled, complying with NEMA PE 5. Provide battery charger/eliminators to meet the following requirements:
 - 1. Rated for continuous operation, float-charging the battery, and for recharging the battery from a cell voltage of 1.1 V to 85 percent of battery capacity in a maximum of 8 hours, while simultaneously supplying the load demands.
 - 2. Input voltage Rating:
 - a. Mainline: 240 Vac, 60 Hz, single phase.
 - b. MSF: 208/120 Vac, 60 Hz, single phase.
 - 3. Output voltage and current: matched to the requirements of the battery and the load.
 - 4. Output voltage regulation: plus or minus 0.25 percent of output voltage over its complete load range with a plus or minus 10 percent variation of input ac voltage. Output ripple shall not exceed 30 mV rms.
 - 5. Output current limiting, adjustable from 90 percent to 115 percent of output nominal current rating, and factory set at 110 percent.
 - 6. Filtered output to maintain ripple within the specified limits when the battery is disconnected.
 - 7. Adjustable 0 to 72 hour equalizing time charger, manually set for supplying an equalizing voltage per cell as recommended by battery manufacturer.
 - 8. Ac Input and Dc Output circuit breakers: Molded-case type complying with the requirements in NEMA AB1.
 - 9. Enclosures: NEMA 250, Type 12 with hinged covers, lockable handles and two point (minimum) latches.
- B. Provide the following additional features/options:
 - 1. Dc voltmeter with 0 V to 200 V range.
 - 2. Dc ammeter.
 - 3. Ac input pilot light marked "AC POWER ON."
 - 4. Two-position selector switch marked "FLOAT" and "EQUALIZE."

5. Output ground fault pilot lights for positive and negative poles.
 6. Input line surge and transient-protective devices.
 7. Battery charger failed alarm.
 8. Battery undervoltage alarm.
 9. Battery overvoltage alarm.
 10. Ground fault alarm.
- C. Send alarms to SAS, as specified in Section 34 21 31, Substation Automation System (SAS).

2.3 BATTERIES

- A. Construction: Low-maintenance, nickel-cadmium, valve-regulated, pocket-plate, stationary type with a minimum of 10-year design life under normal usage for the intended duty, and designed for float service.
- B. Ratings:
1. Ampere-hour capacity: Select in accordance with IEEE 1115 taking into account the calculated loads from all devices, as indicated on the Contract Drawings, for a 10-hour discharge rate to a final cell voltage of 1.0 V for the specified duty cycle.
 2. Battery duty cycle:
 - a. Duration: Period of 10 hours with the battery charger/eliminator out of service, assuming batteries are in a fully charged state at the beginning of the 10 hours.
 - b. Load:
 - 1) Normal continuous demand of the substation auxiliary loads, including relays, indicating lamps, dc-connected lights, and alarm panel.
 - 2) Trip and reclose cycle of one dc feeder breaker every hour.
 - 3) Trip and reclose of the ac breaker after two hours and again after eight hours.
- C. Lockout: Provide a timer such that after a continuous 10 hours of battery charger outage, timer shall trip and lockout the main ac circuit breaker via the 86 relay and trip and lockout the dc circuit breakers via the 186 relays.
- D. Cells:
1. Provide cell assemblies suitable for the required battery duty and a long life-cycle. Support cell elements away from projections in the bottom of the cell container or from the cover.
 2. Clearly and permanently mark polarity of cell terminal posts.
 3. Cell containers: heat and impact resistant translucent or transparent plastic.
 4. Cell filler openings: fitted with an explosion-resistant vent. Mark electrolyte level lines on all four sides of each container.
 5. Provide inter-cell connector buses.
- E. Battery Racks:
1. Provide a four tier structural steel battery support racks.

2. Include insulating plastic strips to cover all supports, hold downs, and restraining rails that are in contact with cells.
 3. Finish with a caustic-resistant paint coat.
- F. Provide an insulating, electrolyte-resistant, plastic mat under each battery rack, extending a minimum of 12 inches outside the rack.
- G. Provide battery bank with a stainless steel nameplate. Nameplate shall be attached to the battery rack using stainless steel rivets and marked with the following information:
1. Manufacturer's name.
 2. Month and year of manufacture.
 3. Battery and cell type.
 4. Ampere rating: 1 minute, 1 hour, and 5 hour.
- H. Provide nickel plated solid copper terminal plates, connectors, plates, and lugs.

2.4 BATTERY SPECIAL TOOLS AND ACCESSORIES

- A. Provide accessories for normal operation and maintenance, including:
1. Cell lifting sling complete with strap and spreader bar.
 2. Battery log book.
 3. Quart of terminal grease, if recommended.
 4. Set of special tools for maintenance.
 5. Set of cell identification numbers.

2.5 FUSED DISCONNECT SWITCH

- A. Provide 2-pole, NEMA 12, fused disconnect switch for isolation of the battery with the following requirements:
1. Rating: 250 Vdc, current rating to match batteries.
 2. NEMA KS 1: Quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position.
 3. Handle lockable in OFF position.
- B. Fuse Clips: Suitable for Class R or J fuses with fuse rejection devices installed.
- C. Fuses: NEMA FU 1 rated to provide short circuit protection for the battery and battery cables.
- D. Coordinate fuse and switch ratings with the output circuit breaker in the battery charger.
- E. Install disconnect switches where indicated on Contract Drawings or required by Codes with external handle centered 60 inches above finished floor or grade level.
- F. Install fuse-rejection devices in fuse clips if required.
- G. Install fuses in fusible disconnect switches.

2.6 DC DISTRIBUTION PANELBOARDS

- A. Comply with requirements of Section 26 24 16, Low-Voltage Panelboards.
- B. Circuit breakers: 125 Vdc, 2-pole.

2.7 DC CONTROL CIRCUIT OVERCURRENT PROTECTION

- A. Within switchgear, dc control circuits shall be protected by mini circuit breakers. Fuses shall not be used.
- B. Mini circuit breakers: 125 Vdc, 1-pole.

2.8 24 VDC POWER SUPPLY

- A. 24 Vdc power supply shall be powered from TPSS 125 Vdc power source.
- B. 24 Vdc power supply shall be redundant:
 - 1. Provide a main 24 Vdc power supply with automatic transfer to a backup 24 Vdc power supply, or operate two 24 Vdc power supplies in parallel.
 - 2. Provide two circuits, each one fed from its own breaker in the 125 Vdc distribution panelboard, to power the two 24 Vdc power supplies.

2.9 FACTORY ASSEMBLY

- A. Install charger, battery rack, and other specified equipment within each substation enclosure secure, plumb and level and in true alignment with related adjoining work.
- B. Install supporting members, fastenings, framing, hangers, bracing, brackets, straps, bolts, and angles as required to set and rigidly connect the Work.
- C. Temporarily install batteries to conduct factory testing, then remove before shipping.
- D. Anti-oxidants and other solvents that can cause cracking of cell jars shall not be used on batteries.

2.10 SOURCE QUALITY CONTROL

- A. Factory Design Tests:
 - 1. Battery: Tests shall comply with IEEE 1106.
 - 2. Battery Charger: Tests shall comply with design tests described in NEMA PE 5.
- B. Factory Production Tests:
 - 1. Test the following:
 - a. Cell voltages.
 - b. Pressure-relief vent operation and reseal.
 - c. Cell jar leakage.

PART 3 - EXECUTION

3.1 FIELD INSTALLATION

- A. Requirements of Article titled "Factory Assembly" apply to field installation.
- B. Following installation of each prefabricated TPSS at site, install battery cells on battery racks.
- C. After battery installation provide an equalizing charge as recommended by battery manufacturer.
- D. Mount battery rack and batteries per seismic requirements.

3.2 FIELD QUALITY CONTROL

- A. Test function of batteries and charging system and test resistance of connections in conformance with Section 34 21 90, Traction Electrification System Testing.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification
SECTION 34 21 31
SUBSTATION AUTOMATION SYSTEM (SAS)

PART 1 - GENERAL

1.1 SUMMARY

- A. SAS in traction power substations (TPSS) including the following:
 - 1. Programmable Automation Controller (PAC).
 - 2. Human Machine Interface (HMI) Display.
 - 3. Industrial Ethernet switch.
 - 4. HMI design and software applications.
- B. SAS/SCADA points list.

1.2 RELATED SECTIONS

- A. Section 26 05 19 – Low Voltage Conductors and Cable
- B. Section 34 21 05 – Common Work Results for Traction Electrification System (TES)
- C. Section 34 21 25 – TPSS Dc Control Power
- D. Section 34 21 80 – TES Spare Parts and Special Tools
- E. Section 34 21 90 – Traction Electrification System Testing

1.3 DEFINITIONS:

- A. Intelligent Electronic Device (IED): See definition in Section 34 21 05, Common Work Results for Traction Electrification System (TES).
- B. SAS: A network of PACs and IEDs in the substation operating as a system for control and monitoring of TPSS equipment.
- C. Supervisory Control and Data Acquisition (SCADA): An industrial control system consisting of SASs and other equipment controlled and monitored by a host workstation, or “Central Control”.
- D. Failure: When an SAS component does not operate as designed.
- E. Repeated failure: Two or more failures of the same component; whether IED, communications interface hardware, related hardware, or software.

1.4 REFERENCE STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents, or if standard is adopted by the City of El Paso, the latest revision adopted:
- B. Institute of Electrical and Electronics Engineers (IEEE)
 - 1. IEEE C37.90, Standard for Relays and Relay Systems Associated with Electric Power Apparatus

2. IEEE C37.90.2, Standard for Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers
 3. IEEE 730, Standard for Software Quality Assurance Plans
- C. International Electrotechnical Commission (IEC)
1. IEC 60529, Degrees of protection provided by enclosures (IP Code)
 2. IEC 60255-21, Electrical Relays – Part 21: Vibration, shock, bump and seismic tests on measuring relays and protection equipment
 3. IEC 61000-4, Electromagnetic compatibility (EMC)
 4. IEC 1131-2, Programmable Controllers – Part 2: Equipment Requirements and Tests
 5. IEC 61131-3, Programmable Controllers – Part 3: Programming Languages
- D. International Organization for Standardization (ISO)
1. ISO 9001, Quality Management Systems – Requirements
- E. National Fire Protection Association
1. NFPA 70, National Electrical Code (with City of El Paso amendments)

1.5 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Design Submittals:
1. A written document describing the design, method of communication, and implementation of the selected communications protocol for the SAS and related components.
 2. Detailed design of the SAS and related components. Refer to Shop Drawings, below.
 3. Submit full-scale color screen shots of SAS applications displayed on the Human Machine Interface (HMI).
 4. Provide documentation demonstrating that specified requirements for service proven design have been met. Include contact information for transit agencies where units are in service.
- C. Product Data: Include technical details and operating manuals of the system and subsystems including hardware, software, MTBF information, communications protocol specifications and show compliance with the specified requirements.
1. PACs.
 2. HMI/Industrial Computer.
 3. Input/Output (I/O) modules
 4. Ethernet switches.
 5. Media converters.
 6. Network cables.
 7. Laptop computer.
 8. HMI Development Software.

D. Spare Parts and Special Tools List:

1. Submit a list of spare parts to be provided under this Section.
2. Submit at the same time as product data.
3. Furnish part numbers for each part, including a detailed break down of each spare part assembly and set, as defined in Section 34 21 80, TES Spare Parts and Special Tools.
4. Submit a list of special tools to be provided under this Section, as defined in Section 34 21 80, TES Spare Parts and Special Tools.

E. Shop Drawings:

1. Block diagrams
2. Input/output maps
3. Equipment layout drawings
4. Ladder logic diagrams
5. Wiring schematic
6. Bill of Materials

F. Software:

1. Provide development software for the SAS, including any software required to program, maintain, and download events/records for the PACs and HMI.
2. Provide source code developed for the PACs and HMI in electronic format as directed by the Engineer.
3. Furnish software licenses for application, interface, development software, and all other software, as described in Software Intellectual Property Rights Section below.

G. Testing:

1. Submit test procedures that meet the requirements of Section 34 21 90, Traction Electrification System Testing, for the following:
 - a. Factory Design Tests.
 - b. Operational Tests.
2. Submit test reports that meet the requirements of Section 34 21 90, Traction Electrification System Testing, for the following:
 - a. Factory Design Tests.
 - b. Operational Tests.

H. System Support Plan for support during commissioning and warranty period.

I. Operations and Maintenance Data:

1. Submit manufacturer's operating and maintenance instructions on products specified in this Section, including the following:
 - a. Submittal information identified above.
 - b. Manufacturer's operating and maintenance instructions, parts list, illustrations and diagram for components.
2. Submit immediately after approval of product data.

1.6 SPARE PARTS

- A. Deliver spare parts in accordance with Section 34 21 80, TES Spare Parts and Special Tools.
- B. List below applies to items in this Specification Section.
 1. PACs: Provide 1 spare of each type used.
 2. HMI and Industrial Computer: Provide 1 spare.
 3. Ethernet switch: Provide 1 spare.
 4. Media converters: Provide 1 spare of each type used.

1.7 QUALITY ASSURANCE

- A. SAS components must be UL labeled.
- B. SAS components that are not UL certified may be furnished with a Field Evaluation label provided by a third party testing laboratory. The testing laboratory shall be approved by the Engineer.
- C. Alarm panel component manufacturers shall be ISO 9001 certified.
- D. A software quality assurance plan shall be used in accordance with IEEE 730. The plan shall describe a mechanism for orderly software development.

1.8 SOFTWARE INTELLECTUAL PROPERTY RIGHTS

- A. Furnish an irrevocable license to Owner for application software developed under this Contract, including source code.
- B. Furnish an irrevocable license to Owner for interface software for SAS components.
- C. Furnish an irrevocable license to Owner for development software for SAS components and HMI.

1.9 REQUIREMENTS FOR SERVICE PROVEN DESIGN

- A. SAS components and software shall be of a proven design. Provide evidence of at least 15 identical units that have been in successful operation in rail transit projects for a minimum of 3 years.

1.10 RELIABILITY AND MAINTAINABILITY

- A. SAS shall be fail-safe, such that a hardware or software failure condition shall not result in an unsafe equipment state.
- B. Failure of an SAS component shall not damage other equipment or inhibit status indication of the equipment.

- C. Investigate repeated failure in the SAS and provide a failure analysis report outlining the root cause of failure. Provide recommendations for correcting the failure and apply the corrective action at no cost to the Owner.
- D. The following components shall have a minimum mean time between failure (MTBF):
 - 1. PAC: 100,000 hours
 - 2. HMI: 50,000 hours
- E. SAS shall be capable of accommodating upgrades, bug-fixes, patches and modifications.
 - 1. Monitor the need for system modifications and supply such changes at no additional cost to the Owner for a period of 5 years.
 - 2. Fully document changes and submit documentation to the Engineer.

1.11 ENVIRONMENTAL REQUIREMENTS

- A. SAS components shall be designed to operate in the environment in which they will be installed and shall comply with and fully function in the environmental conditions specified in Section 34 21 05, Common Work Results for Traction Electrification System (TES).
- B. Electrical interfaces shall meet the applicable ANSI and IEEE Standards for service, EMI immunity, and surge-withstand requirements.
- C. The presence of transients on communication interfaces shall not cause disoperation or blocking of critical communications.

1.12 WARRANTY

- A. Provide on-site and remote support for the specified SAS throughout the entire warranty period. Support shall include assistance with operation and maintenance of the system.
- B. Develop a comprehensive System Support Plan and submit to Engineer.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Provide an SAS for monitoring and control of traction power substation equipment at each TPSS capable of interfacing with other SASs and SCADA.
- B. SAS shall consist of the following components:
 - 1. Programmable logic controllers (PAC) or industrial computers.
 - 2. HMI panel/Industrial Computer.
 - 3. Ethernet switch.
 - 4. Media converters.
 - 5. Network cables.
 - 6. Power supplies.
- C. Devices shall use commercial off-the-shelf products to minimize integration and future maintenance efforts.
- D. Devices shall be of the same brand and model with similar modules and programming to achieve similarity between substations.

- E. Provide terminal blocks, in accordance with Section 34 21 05, Common Work Results for Traction Electrification System (TES), and wiring as required for alarms.
- F. SAS components shall comply with the following requirements:
 - 1. Mechanical shock and bump withstand level: IEC 60255-21-2, Response and Withstand Section, Class 1.
 - 2. Vibration withstand level: IEC 60255-21-1, Response and Withstand Section, Class 2.
 - 3. Seismic withstand level: IEC 60255-21-3, Class 2.
 - 4. Electromagnetic field impulse withstand level: IEC 61000-4-3, 10 V/m.
 - 5. Electromagnetic field radio frequency withstand level: ANSI C37.90.2, 35 V/m.
 - 6. Storage Temperature: Minus 20 degrees to 60 degrees C.
 - 7. Operating Temperature: Zero degrees to 40 degrees C.
 - 8. Maximum humidity: 90 percent without condensation.
 - 9. Provide product data verifying compliance.
- G. SAS I/O Design:
 - 1. Provide a list of all SAS component I/O and incorporate in the design for monitoring and indication to the HMI.
 - 2. Provide 10 additional I/O points at each TPSS for indication or monitoring upon request at no additional cost to the Owner.
- H. SAS component memory and removable storage shall be solid-state, non-volatile, and shall not utilize mechanically-driven (hard-drive based) components.
- I. SAS shall be designed such that no supply-power fault will result in loss of data or require any manual re-work such as programming or reconfiguration.

2.2 POWER REQUIREMENTS

- A. SAS and PAC shall be powered by 125 Vdc plus or minus 15 percent or 24 Vdc plus or minus 20 percent. See Section 34 21 25, TPSS Dc Control Power for requirements.

2.3 TIME SYNCHRONIZATION

- A. Synchronize SAS components as follows:
 - 1. PAC and IEDs.
 - 2. SAS with other SASs.
 - 3. SAS with NTP server.
- B. Provide SAS must synchronize using SNTP.
- C. Use of the PAC as a time server is acceptable.
- D. A dedicated time source such as a GPS clock is acceptable.

2.4 SAS NETWORK

- A. Connect IEDs to the SAS via Ethernet over fiber.
- B. Use VLANs for transfer trip between dc relay IEDs through the communications network.
- C. Communications Protocol: Ethernet TCP/IP, Modbus TCP/IP, or approved equal.

2.5 PAC

- A. Provide PACs at each TPSS for interfacing with other SAS components equipped with the following:
 - 1. Chassis or backplane.
 - 2. Redundant power supplies.
 - 3. Primary central processing unit (CPU).
 - 4. I/O modules.
 - 5. Ports: RJ45, RS232/RS485, USB.
 - 6. Removable flash memory with a minimum of 1GB.
 - 7. Resident executable program and code.
 - 8. Communication Protocols: Modbus TCP/IP, DNP3, Profinet, Ethernet TCP/IP.
- B. PAC shall provide the following functions:
 - 1. Monitor and control of TPSS equipment.
 - 2. Log substation alarms and events as a server. The use of a dedicated or separate event log server is acceptable.
 - 3. Operate independently of a failure of any other SAS component or their intercommunications.
 - 4. Retain programming, configuration and memory (including data logs) even with loss or degradation of supply power.
- C. Repair and Replacement:
 - 1. PAC and associated modules shall be replaceable on site without requiring factory rewiring.
 - 2. PAC modules shall have free-standing terminals to allow changing modules without disturbing field wiring.
- D. Programming facilities (logic, available functions and supported data types) shall be non-proprietary and shall either be compliant with IEC 61131-3 or shall use the C or C++ standard programming languages.

2.6 HUMAN MACHINE INTERFACE (HMI) HARDWARE

- A. Provide an industrial touch screen monitor with industrial computer for the SAS HMI that is compatible with the PAC for controlling TPSS equipment and monitoring TPSS events and alarms.
- B. HMI and ancillary devices shall be flush mounted in a door of the dc switchgear.
 - 1. Locate at a height appropriate for easy access by a person of average height.
 - 2. Locate such that a person standing in front of the HMI is not standing in front of a circuit breaker.
- C. Screen:
 - 1. Minimum TFT 24-bit color LCD.
 - 2. Touch screen: Resistive or capacitive.
 - 3. Size: Minimum 19-inches diagonal.
 - 4. Resolution: Minimum 1280 x 1024 pixels.
 - 5. Brightness: Minimum 420 cd/m².
 - 6. Contrast Ratio: 1000:1.
- D. Input: VGA, DVI, HDMI, USB.
- E. Industrial Computer
 - 1. Provide an industrial computer for interfacing with the PAC through the TPSS LAN and run HMI touch screen applications for display on the HMI screen.
 - 2. Interface with the TPSS LAN must use Ethernet.
 - 3. Specifications:
 - a. Rack mountable
 - b. Intel Core i7
 - c. 16GB RAM
 - d. DVI, HDMI ports
 - e. Ethernet, USB 3.0 ports
 - f. 256GB SSD Hard Drive
 - g. Windows Latest Version
 - h. Operating Temperature: -40 to 74 degrees C
 - i. Alarm Output for Monitoring
 - j. Dual Power supply

2.7 HMI DESIGN AND SOFTWARE APPLICATIONS

- A. Provide HMI and software applications similar to the layouts shown on Contract Drawings.
- B. Design:
 - 1. Navigation bar:
 - a. Accessible from any application.
 - b. Contains buttons to navigate to other applications.
 - 2. Buttons, text, and icons:
 - a. Sized appropriately for ease of use.
 - b. Designed with button responses to show button actions, e.g. selected, not selected.
 - c. Intuitively designed and representative of the equipment being monitored or controlled.
 - 3. Input keyboards:
 - a. Alpha: QWERTY.
 - b. Numeric: 10-key.
 - c. Automatically display the appropriate keyboard when an input is required.
 - d. Provide a cancel button that closes the keyboard.
- C. Provide the following HMI software applications:
 - 1. Header Screen:
 - a. Displayed at all times and similar in design to what is shown on Contract Drawings.
 - b. Display the time, date, name of substation, system name, and SCADA control panel.
 - c. Time and Date:
 - 1) Time shall be synchronized with PAC.
 - 2) Time format: 00:00:00.
 - 3) Date format: December 10, 2013.
- D. Control Screen:
 - 1. Displays equipment status and provides local control of TPSS equipment.
 - 2. Status indications:
 - a. Display in real time and refresh at least every second.
 - b. Display local/remote status for each breaker.
 - c. Display test/disconnected status for each breaker.

- d. Display energized/de-energized status for equipment.
 - e. Display opened/closed status of disconnect switches.
 - f. Display adjacent TPSS breaker energized/de-energized status.
3. Color Code:
- a. Energized Equipment: Red.
 - b. De-energized Equipment: Green.
 - c. Uncertain Equipment State: Grey.
 - d. Color shall indicate the energized, de-energized, or uncertain state of each piece of equipment, including the busbar, feeder cables, transformer, and rectifier.
4. Control operation:
- a. Control operation sequence:
 - 1) Select object.
 - 2) Confirm object selection (confirm or cancel).
 - 3) Select operation (close, open, or cancel).
 - 4) Confirm operation (confirm or cancel).
 - b. A combined message window shall not be used; each step shall have an individual window.
 - c. Selection, confirmation, and execution information must be clear and displayed without abbreviations.
 - d. Selection and confirmation of operation shall be automatically cancelled after 60 seconds if the operation is not executed.
 - e. Provide a cancel button for each control step.
5. Bypass Load Measuring:
- a. Provide option for dc breaker close operation that allows selection of bypass mode, which bypasses the load measuring system.
 - b. Upon confirmation of this operation, a warning shall flash on the screen stating "LOAD MEASURING BYPASSED."
6. Password Protection:
- a. Selection of an object shall be password protected.
 - b. Selection of bypass load measuring shall require an additional level of password protection.
7. If a protection function is triggered, the related equipment alarm field shall flash until it is acknowledged.

E. Alarm Screen:

1. Display each alarm shown in Alarm Points List, at the end of this Section.
2. Layout: See Contract Drawings.
3. New Alarm: Flashing red.
4. Acknowledged alarm: Solid red.
5. New alarms resolved before acknowledgment: Flashing yellow.
6. Resolved Alarm: Grey.
7. Alarms shall be acknowledged by touching an Acknowledge button.
8. The Alarms button in the navigation bar must follow the same color logic as above.

F. Events Screen:

1. Layout and Format: See Contract Drawings.
2. Log each alarm and equipment event with time and date stamp.
3. Event log shall display a minimum of 500 events. Implement page turn buttons to view alarms exceeding the length of one page.
4. Events must not be capable of being deleted.
5. Overwrite the oldest entry in the log with new events over the 500th entry.
6. Display the most recent entry at the top of the screen.
7. Events shall be downloadable to a laptop and USB flash drive without deletion from the SAS.
8. File format: Compatible with Microsoft Excel.

G. Network Status Screen:

1. Layout: See Contract Drawings.
2. Application must indicate the communication/operational status of each SAS component.
3. Normal: Green.
4. Error: Red.
5. Unknown: Yellow.

H. Settings Screen:

1. Provide a settings screen application for adjusting time, editing user management/password settings, editing alarm screen windows, and viewing PAC I/O Status.
2. Time setting: Provide both manual adjustment options and automatic SNTP synchronization with an NTP server.
3. Viewing permissions: No password required.
4. Editing permissions: Password required.

- I. Help Screen:
 - 1. Provide a help screen containing operational instructions and descriptions for the SAS HMI applications described above.
 - 2. Organize and display help topics in an outline format with individual topics that expand to display information when selected.

2.8 DEVELOPMENT SOFTWARE

- A. Provide a user-friendly PC/Windows based development environment suitable for application software updating and modification.
- B. The environment shall be dedicated solely to creating control/monitoring software. It shall use familiar, standardized editors bundled into a single application.
- C. The environment shall include a graphics editor and online help that simplify development of application software.
- D. The environment shall comply with Microsoft Windows Graphical User Interface (GUI) and IEC 61131-2 standards for programmable logic controllers.
- E. Provide de-bug, documentation and machine startup facilities in the environment.
- F. Provide complete user training for the application of development environment in accordance with Section 01 79 00, Demonstration and Training.
- G. Provide complete user documentation for the environment complying with Section 01 78 23, Operations and Maintenance Data.
- H. Software must be compatible with Windows, Latest Version.
- I. Approved Manufacturer: Wonderware, Vijeo Designer, or approved equal.

2.9 ETHERNET SWITCH

- A. Provide industrial managed Ethernet switches for connecting SAS components and SCADA.
- B. Ports:
 - 1. Copper: 10/100/1000 Base T RJ45.
 - 2. SFP: 100/1000 base-X for fiber.
 - 3. Spare: 20 percent.
- C. Layer 2 Function:
 - 1. VLAN: Up to 8 groups.
 - 2. Port Configuration.
 - 3. QoS.
 - 4. Security: MAC filter, switch access.
- D. Operating temperature: minus 40 to 70 degrees C
- E. Redundant power supply.

2.10 LAPTOP COMPUTER

- A. Provide a laptop computer suitable for use to interface with the SAS and other IEDs in the TPSS LAN.
- B. Development and interface software for IEDs and SAS components must be preinstalled on the computer.
- C. End user software and firmware developed for IEDs and SAS components must be loaded on the laptop computer with files descriptively labeled showing their intended purpose.
- D. Specifications:
 - a. Intel Core i7
 - b. 16GB RAM
 - c. VGA, HDMI ports
 - d. Ethernet, USB 3.0 ports
 - e. 256GB SSD Hard Drive
 - f. Windows, Latest Version
 - g. 14-inch HD display
 - h. LTE mobile broadband
 - i. MIL-STD-810G certified for shock, drop, vibration, temperature and humidity
- E. Approved Manufacturer: Panasonic Toughbook 53 or approved equal.

2.11 INTERIOR BLUE LIGHT AND RESET SWITCH

- A. Provide a blue light LED for TPSS alarm indication located above the HMI panel.
- B. The blue light shall have a label "SUBSTATION TROUBLE ALARM."
- C. The light shall operate as follows:
 - 1. Light flashes when an SAS alarm/event occurs.
 - 2. Light is solid when all alarms are acknowledged.
 - 3. Light turns off when all alarms are resolved.
- D. Alarm acknowledgement shall be provided by a button on the HMI.
- E. Blue light shall be fail safe.

2.12 EXTERIOR BLUE LIGHT

- A. Activate exterior blue lights (see Section 34 21 05, Common Work Results for Traction Electrification System (TES) for the following alarms:
 - 1. Smoke alarm.
 - 2. Intrusion Zone 1 alarm (entry doors).
 - 3. Intrusion Zone 2 alarm (exterior equipment access doors).
 - 4. Ac breaker trip.

5. Dc breaker trip without reclose.
 6. Traction power transformer over temperature (first stage).
 7. Rectifier over temperature (first stage).
 8. Substation high temperature.
 9. Diode failure.
 10. Frame fault.
- B. For Intrusion Zone 1 alarm, provide a time delay, and an override in the HMI only, to allow authorized persons to enter the substation and override the alarm without activating the exterior blue light.

2.13 FACTORY ASSEMBLY

- A. SAS hardware installation shall be identical and interchangeable between substations, including wire numbering, and marking.
- B. Wiring: Interconnecting wiring shall be 14 AWG 600 V switchboard wire in accordance with Section 26 05 19, Low Voltage Conductors and Cable.
- C. Wire and Cable Identification:
1. Wire and cables shall be identified whenever they enter or leave a housing or enclosure, and at all terminals.
 2. Provide labels in accordance with Section 26 05 19, Low-Voltage Conductors and Cable.
- D. Terminals: DIN rail mounted.
- E. Spare Capacity:
1. Design system with a minimum of 30 percent spare capacity. This shall include:
 - a. Wiring terminals.
 - b. Inputs and outputs of same kind per modular controller unit.
 - c. Spaces for additional modules for each modular PAC unit.
- F. Workmanship:
1. Install equipment, enclosures, wire, cable, conduits and wireways in a neat and secure manner, level and plumb, and in true alignment with adjoining work.
 2. Equipment enclosures and installation shall comply with local and national codes including, but not limited to UL 508A and NFPA 70.

2.14 ALARMS POINTS LIST

- A. Provide the following points for control and monitoring by the SAS and future SCADA at each TPSS:

Device	Description	Device No	Status	Control
Ac Circuit Breaker and Protective Relay	Breaker closed/open status	52	X	
	Breaker test/disconnected status		X	
	Remote Trip Command		X	X
	Remote Close Command		X	X
	Undervoltage	27	X	
	Overvoltage	59	X	
	Loss of Control power	27ac	X	
	Phase Sequence	47	X	
	Time Delay Overcurrent Phase	51	X	
	Instantaneous Overcurrent Phase	50	X	
	Time Delay Overcurrent Neutral	51N	X	
	Instantaneous Overcurrent Neutral	50N	X	
	Local/Remote Indication		X	
	Access Door	33ac	X	
	Ac Breaker Trip Healthy Coil		X	
	Ac Lockout Relay Healthy Coil		X	
	Ac Protective Relay Status		X	
	Ac Lockout Relay	86	X	
Power Meter	V, A, kW, kVAr, kWh		X	
Dc Feeder Breaker and Protective Relay (for each feeder breaker)	Breaker closed/open status	172	X	
	Breaker test/disconnected status		X	
	Remote Trip Command		X	X
	Remote Close Command		X	X
	Local/Remote Indication	43	X	
	Incomplete Sequence	148	X	
	Overvoltage	159	X	
	Undervoltage	127	X	
	Rate of Rise di/dt	151	X	
	I _{max}	150	X	
	Loss of Control power	27dc	X	
	Dc Voltage		X	
	Dc Current		X	
	Transfer Trip	85	X	X
	Transfer Trip Lockout	85L	X	X
	Access Door	33dc	X	

Positive Disconnect Switch	Open Indication		X	
	Close Indication		X	
Negative Disconnect Switch	Open Indication		X	
	Close Indication		X	
Traction Power Transformer	Over Temperature 1 Alarm	49T1	X	
	Over Temperature 2 Trip	49T2	X	
Rectifier	Over Temperature 1 Alarm	26R1	X	
	Over Temperature 2 Trip	26R2	X	
	Temp Monitor Status		X	
	Diode Failure 1 Alarm	98R1	X	
	Diode Failure 2 Trip	98R2	X	
	Rear Access Door	33R	X	
	Reverse Current	32	X	
Battery Charger	Undervoltage	27Batt	X	
	Overvoltage	59Batt	X	
	Charger Summary Alarm		X	
TPSS General	ETS	5	X	
	High Temperature Alarm		X	
	Smoke alarm		X	
	Intrusion Zone 1 (access doors)		X	
	Intrusion Zone 2 (exterior equipment access doors)		X	
	HVAC 1 Status Alarm		X	
	HVAC 2 Status Alarm		X	
Rail-to-Ground Monitor	Timed Overvoltage		X	
	Instantaneous Overvoltage		X	
	Timed Overcurrent		X	
	Instantaneous Overcurrent		X	
	R2G Status		X	
Ground Fault Detector	Grounded Structure Alarm	64GS	X	
	Hot Structure Trip	64HS	X	
SAS	PAC Status		X	
	Network Switch Status		X	
	IED Status		X	
	HMI Status		X	

2.15 SOURCE QUALITY CONTROL

A. Factory Design Tests:

1. Perform with all accessories attached in accordance with design tests in IEEE C37.90.
2. Demonstrate electrical operation and accuracy of all components.
3. Test from alarm panel to initiating devices for proper operation.

B. Factory Production Tests:

1. Test all components for proper operation and function.
2. Test control wiring continuity by actual electrical operation of control devices.
3. Test inputs and outputs for proper operation and short circuits.
4. Communications: Verify communications and SCADA information is retrievable.
5. HMI: Verify that display, screens, and user interface operate in accordance with Specifications.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install SAS in MSF substation as required in Part 2, above, in the article titled "Factory Assembly."

3.2 INTEGRATION WITH SCADA NETWORK

- A. Program and configure SAS switches and SAS components to establish communication between substations and to a host SCADA workstation over the SCADA network.
- B. Configure dc multifunction IEDs and SAS components to communicate transfer trip signals over the communications network using VLAN.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 34 21 33 RAIL-VOLTAGE MONITORING AND GROUNDING SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

- A. Requirements for the Rail Voltage Monitoring and Grounding System for each mainline traction power substation.
- B. Rail Voltage Monitoring and Grounding System includes a bi-directional switching device and an integrated Device 64V protective relay function for voltage and current monitoring and tripping of dc feeder circuit breakers.

1.2 RELATED SECTIONS

- A. Section 26 05 19 – Low-Voltage Conductors and Cable
- B. Section 34 21 05 – Common Work Results for Traction Electrification System (TES)
- C. Section 34 21 25 – TPSS Dc Control Power
- D. Section 34 21 31 – Substation Automation System (SAS)
- E. Section 34 21 80 – TES Spare Parts and Special Tools
- F. Section 34 21 90 – Traction Electrification System Testing

1.3 ABBREVIATIONS AND ACRONYMS

- A. Rail-to-Ground System: Rail-Voltage Monitoring and Grounding System.
- B. R2G: Rail Voltage Monitoring and Grounding System.
- C. SAS: Substation Automation System

1.4 DEFINITIONS

- A. Controller:
 - 1. A programmable logic controller (PLC) and human machine interface (HMI) device.
- B. Rail voltage:
 - 1. Zero potential: Equal to earth potential.
 - 2. Positive voltage: Ground positive with respect to rail.
 - 3. Negative voltage: Ground negative with respect to rail.
- C. Current:
 - 1. Positive current is current that flows from ground to rail.
 - 2. Negative current is current that flows from rail to ground.

1.5 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Product Data:
 - 1. Product descriptions and catalog data for system components.
 - 2. Information concerning design and application ratings.
 - 3. Information concerning service, performance and reliability and locations where units are currently in service.
 - 4. Measures used to prevent failure of switch.
- C. Spare Parts and Special Tools:
 - 1. Submit a list of spare parts to be provided under this Section.
 - 2. Submit at the same time as product data.
 - 3. Provide part numbers for each part, including a detailed breakdown of each spare part assembly and set, as defined in Section 34 21 80, TES Spare Parts and Special Tools.
 - 4. Submit a list of special tools to be provided under this Section, as defined in Section 34 21 80, TES Spare Parts and Special Tools.
- D. Shop drawings:
 - 1. Manufacturer's arrangement and outline dimensions for each device.
 - 2. Logic diagram.
 - 3. Wiring schematics.
 - 4. Connection diagrams.
 - 5. HMI screen shots.
- E. Submit test procedures that comply with Section 34 21 90, Traction Electrification System Testing.
 - 1. Design Test.
 - 2. Production Tests: Provide production test reports for each component.
- F. Submit test reports that comply with Section 34 21 90, Traction Electrification System Testing.
 - 1. Design Test.
 - 2. Production Tests: Provide production test reports for each component.
- G. Operation and Maintenance Data:
 - 1. Submit manufacturer's operating and maintenance instructions on products specified in this Section, including the following:
 - a. Submittal information identified above.
 - b. Parts list, illustrations and diagram for components for products specified in this Section.
 - c. Wiring diagram.

2. Submit immediately after approval of product data.

1.6 SPARE PARTS

- A. Provide spare parts in accordance with Section 34 21 80, TES Spare Parts and Special Tools.
- B. List below applies to items in this Specification Section.
 1. Rail-to-Ground System complete assembly, including PLC, HMI, and switch: Provide 1 assembly.
 2. Enclosure door key: Provide 2 spare keys for each substation.

PART 2 - PRODUCTS

2.1 RAIL-TO-GROUND SYSTEM (R2G)

- A. General Requirements:
 1. Provide an R2G at each traction power substation for monitoring and protecting against rail-to-ground overvoltages and overcurrents.
 2. R2G shall be of proven design with minimum 3-years successful operation in a rail application.
 3. R2G shall be a self-contained unit with a bi-directional switching element, voltage transducer, current transducer, and PLC/HMI controller suitable for use in a 750 Vdc traction power system.
- B. Controller:
 1. Dedicated PLC.
 2. Form C contacts for overvoltage, overcurrent, and summary alarm signals.
 3. Sufficient memory to store 500 events
- C. HMI Display:
 1. Type: Industrial LCD touch screen monitor with resistive touch.
 2. Size: 12-inch active matrix, minimum.
 3. Color: 18-bit color.
 4. Resolution: 800 x 600.
 5. Contrast Ratio: 600:1.
- D. Bi-Directional Switch:
 1. Composed of phase-controlled stud-type thyristors.
 2. Continuous Current Rating: Minimum 800 A.
 3. Current Withstand: 30 kA for 100 ms and 50 kA for peak value half sine wave.
- E. Enclosure: Steel, with a latching access door that is lockable; all enclosures keyed alike.

- F. LED indications:
 - 1. Provide LED indicators mounted on the enclosure
 - a. Red LED: Switch is closed and conducting
 - b. Yellow LED: Event has occurred. LED will remain flashing until acknowledged.
- G. Acknowledge Button:
 - 1. Provide a momentary push button on the outside of the enclosure for the local acknowledgement of the yellow LED event alarm
- H. Control power: Refer to Section 34 21 25 TPSS Dc Control Power
- I. Communications:
 - 1. Protocol: Modbus TCP/IP, Ethernet TCP/IP, or approved equal.
 - 2. Device shall be capable of being remotely monitored by the SAS, as specified in Section 34 21 31, Substation Automation System (SAS), and future SCADA.
 - 3. R2G shall communicate alarms and switch status to the SAS.

2.2 HMI APPLICATION DESIGN

- A. General Design Requirements:
 - 1. Provide HMI applications for displaying event notifications, rail voltage and current data, and device configuration information.
 - 2. HMI must provide a means of field programming time and date, voltage and current triggers, and communications settings.
 - 3. HMI must have password protection for functions related to changing the configuration of the device.
 - 4. Current date and time must be displayed at all times.
 - 5. R2G must synchronize time and date with the SAS.
- B. Event Log:
 - 1. Record events and retain for seven days minimum in non-volatile memory.
 - 2. Create events for the following:
 - a. Overvoltage;
 - b. Overcurrent;
 - c. Switch trigger;
 - d. Thyristor fail;
 - e. Breaker trip;
 - f. Breaker lockout;
 - g. R2G fault.
 - 3. Events must be date and time stamped.

4. Events shall be downloadable onto a laptop computer and USB thumb drive.
 5. Event log must be viewable using Microsoft Excel.
 6. See Section 34 21 05, Common Work Results for Traction Electrification System (TES), for requirement to supply software.
- C. Waveform Capture:
1. Log and capture voltage and current data upon voltage and current triggers.
 2. Waveform information shall be downloadable onto a laptop computer and USB thumb drive.
 3. Waveform information must display the voltage and current before and after the trigger event.
 4. Log must be viewable using Microsoft Excel.
- D. Overvoltage Protection:
1. Long-Time Overvoltage:
 - a. Voltage setting range: 0 to 200 V, positive or negative, in 1 V increments.
 - b. Time delay setting range: 0 to 20 seconds in 0.1-second increments.
 - c. Default setting: Plus/minus 50 V and 10-second delay.
 2. Short-Time Overvoltage:
 - a. Voltage setting range: 0 to 200 V, positive or negative, in 1 V increments.
 - b. Time-delay setting range: 0 to 10 seconds in 0.1-second increments.
 - c. Default setting: Plus/minus 95 V and 1-second delay.
 3. Each voltage trigger shall close the R2G switch.
- E. Switch Operation:
1. Time duration of closure shall be dependent on the current flowing through switch and the natural characteristics of the thyristor.
 2. Provide an option for disabling conduction of the switch in each direction. This option must be field adjustable using the HMI.
- F. Overcurrent Protection:
1. When switch is conducting, the R2G shall monitor current through the switch and provide two overcurrent-protection triggers.
 2. Long-time overcurrent:
 - a. Current setting range: 0 to 800 A, positive or negative, in 1 A increments.
 - b. Time-delay setting range: 0 to 60 seconds in 0.1-second increments.
 - c. Default setting: Plus/minus 5 A and 50-second delay.
 3. Instantaneous overcurrent:
 - a. Current setting range: 0 to 1000 A, positive or negative, in 1 A increments.

- b. Time-delay setting range: 0 to 60 seconds in 0.1-second increments.
 - c. Default setting: Plus/minus 20 A and 0.5-second delay.
- 4. Each overcurrent stage shall trigger any one of three user-selectable responses:
 - a. Trip and reclose dc breakers with breakers reclosing one-by-one.
 - b. Trip and lockout dc breakers.
 - c. Trip and lockout dc breakers and transfer trip adjacent substations.
- 5. The R2G shall trip and lockout the breaker on a repeat overcurrent trigger if it occurs within a user-adjustable time. The user-adjustable settings are as follows:
 - a. Repeat Trigger Function: Enabled, Disabled.
 - b. Time-Window Setting range: 2 to 60 seconds in 1-second increments. The setting shall not be less than the instantaneous-overcurrent time delay.
 - c. Default setting: 60 seconds.
- G. If the current or voltage value measured by the R2G is lower than its setting, the grounding device counters shall be reset.
- H. R2G shall be fail-safe as described in the following two scenarios, at minimum:
 - 1. A malfunction of the control component shall cause grounding switch to close until control component is restored.
 - 2. An alarm signal shall be sent to SAS if a thyristor or control component fails.

2.3 CONNECTIONS

- A. Ground R2G enclosure and internal ground reference busbar to the structure earth using 4/0 copper, 2 kV insulated cable, as specified in Section 26 05 19, Low-Voltage Conductors and Cable.
- B. Connect the R2G negative reference to the negative return using 4/0 copper 2 kV insulated cable.

2.4 SOURCE QUALITY CONTROL

- A. Design Tests:
 - 1. Perform on the first unit in compliance with requirements for design tests in Section 34 21 90, Traction Electrification System Testing.
 - 2. Heat run test to verify 800A continuous current rating.
 - 3. Operational tests verifying the requirements in this section.
- B. Production Tests:
 - 1. Perform on each unit before in compliance with requirements for production tests in Section 34 21 90, Traction Electrification System Testing.
 - 2. Operational tests verifying the requirements in this section.

PART 3 - EXECUTION

Not Used

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 34 21 40 DC DISCONNECT SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

- A. Manual, no-load-break, non-grounding, pole-mounted dc disconnect switches mounted inside non-metallic switch enclosure for installation on tapered tubular poles to connect/disconnect two adjacent sections of OCS.
- B. Manual, no-load-break, non-grounding, wall-mounted dc disconnect switches to connect/disconnect dc power to Maintenance Shop Facility (MSF) OCS.

1.2 RELATED SECTIONS

- A. Section 26 05 00 – Common Work Results for Electrical
- B. Section 34 21 05 – Common Work Results for Traction Electrification System (TES)
- C. Section 34 21 90 – Traction Electrification System Testing

1.3 REFERENCE STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents, or if standard is adopted by the City of El Paso, the latest revision adopted:
- B. ASTM International (ASTM)
 - 1. ASTM B187/B187M, Standard Specification for Copper, Bus Bar, Rod and Shapes and General Purpose Rod, Bar, and Shapes
- C. Institute of Electrical and Electronics Engineers (IEEE)
 - 1. IEEE C37.34, Standard Test Code for High-Voltage Air Switches
- A. National Fire Protection Association (NFPA)
 - 1. NFPA 70, National Electrical Code (with amendments by the Authority Having Jurisdiction)

1.4 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Product Data: Complete manufacturer's descriptions, catalog data, materials and information including model numbers.
 - 1. Isolation method, circuit and wiring diagrams.
 - 2. Operating mechanism and assembly details.
- C. Manufacturer's installation instructions.

D. Shop Drawings:

1. Manufacturer's general and detail arrangement and dimensional drawings.
 - a. The shop drawing for each assembly shall be referenced with the assembly reference and shall represent in full the equivalent project assembly drawing.
 - b. Each shop drawing shall provide a complete list of its component materials for that specific type of assembly, including the identification of materials to be supplied by others, such as pipes, brackets, bolts, cables, jumpers and cable connectors.
2. Switch designs of each switch type.
3. Detailed drawings showing mounting brackets and mounting for each type of switch mounting. Submit for approval before installing the first switch.

E. Manufacturer's recommended installation instructions, including checks/tests after installation.

F. Manufacturer's certification that each switch has been correctly installed and adjusted.

G. Submit test procedures that comply with Section 34 21 90, Traction Electrification System Testing.

1. Design Tests.
2. Production Tests.

H. Submit test reports that comply with Section 34 21 90, Traction Electrification System Testing.

1. Design Tests: Provide design test reports for each type of disconnect switch within 30 Days after completion of testing.
2. Production Tests: Provide production test reports for each disconnect switch within 30 Days after completion of testing.

I. Operations and Maintenance Data:

1. Submit manufacturer's operating and maintenance instructions on products specified in this Section, including the following:
 - a. Submittal information identified above.
 - b. List of recommended spare parts.
2. Submit immediately after approval of product data.

PART 2 - PRODUCTS

2.1 TYPE

- A. Pole Mounted: Single-pole, single-throw, non load-break, bolted pressure, non-grounding, mounted inside a non-metallic enclosure with a manual operator. Design shall comply with the applicable requirements given in IEEE C37.34 and ASTM B187/B187M.
- B. Wall Mounted: Single-pole, single-throw, non load-break bolted pressure switch, non-grounding with manual operator. Provide with auxiliary contacts for indicating switch position and for shop equipment interlocking. Design shall comply with the applicable requirements given in IEEE C37.34 and ASTM B187/B187M.
- C. Switch shall be suitable for mounting on pole or on shop wall, as indicated on Contract Drawings.

2.2 SWITCH RATINGS

- A. Voltage: 1000 Vdc.
- B. Minimum insulation level: 3.7 kV rms.
- C. Continuous current rating: 1000 A; switch contact temperature rise shall not exceed 50 degrees C above a maximum ambient temperature of 40 degrees C.
- D. Momentary peak current withstand: Not less than 90 kA.
- E. Short time current: Not less than 70 kA, average, for 0.25 seconds.

2.3 SWITCH

- A. Switch Contacts:
 - 1. Moving and stationary contact surfaces shall be silver-plated copper.
 - 2. Contacts shall be self-aligning, wear-compensating, with wiping action on switch closing.
 - 3. Hinge and jaw contacts shall be bolted-pressure type with non-ferrous or stainless steel self-clamping mechanism, or other approved high-pressure type contact arrangement.
- B. Other current-carrying parts: High conductivity copper or copper alloy.
- C. Switch shall be capable of breaking load currents under emergency conditions.
- D. Auxiliary Contacts: Isolated from 600/750 Vdc to prevent inadvertent shorting of 600/750Vdc with low voltage control signals used for switch position and interlocking.

2.4 MANUAL OPERATOR

- A. General:
 - 1. Each switch shall have a manual operating mechanism for operation of switch.
 - 2. Operating mechanism shall operate smoothly and easily
 - 3. Exposed outdoor switches shall be capable of operation with a 1/4-inch thick covering of glazed ice on the external switch mechanism.
 - 4. Closed position shall have the handle in the up position.
 - 5. Provide "OPEN" and "CLOSED" plates.
- B. Wall-Mounted Switch:
 - 1. Provide insulated linkage from handle at floor level to switch.
 - 2. Handle shall be lockable in the open or closed position with a pad lock.
- C. Pole-Mounted Switch:
 - 1. Provide a dead-front operating handle and linkage inside the enclosure.
 - 2. Operating handle shall be suitable for operation from ground level with a hot stick.
 - 3. Padlock:
 - a. Outdoor-type with weather cover, heavy duty, keyed padlock, with minimum 2-inch hasp.

- b. Master Lock Pro Series No. 6121, or approved equal.
- c. Key as directed by Engineer.
- d. All locks keyed alike.

2.5 INSULATION

- A. Switch assembly shall have double insulation, consisting of two independent insulators each rated for the system voltage, as follows:
 - 1. Between the switch and the operating handle.
 - 2. Between the switch and the pole or wall upon which it is mounted.

2.6 POLE-MOUNTED SWITCH ENCLOSURE

- A. Description:
 - 1. Rigid, fiberglass-reinforced polyester.
 - 2. Rain-tight, with design conforming in general to NEMA 250 Type 4X.
 - 3. Weatherproof, heavy service construction, tamperproof design suitable for outdoor application.
 - 4. Ventilated with hooded openings with screens.
 - 5. Drain hole in the base.
- B. Size and Arrangement:
 - 1. Size enclosure to accommodate switch, internal linkages, operating gear, cabling, and terminations without electrical shorting or damage due to chafing on feeder cable insulation.
 - 2. Maintainable components shall be readily accessible through the door opening.
 - 3. Provide sufficient space for the manipulation of required tools.
- C. Materials and Construction:
 - 1. Minimum of 1/4-inch thick polyester with 40 percent glass fiber and 60 percent resin.
 - 2. Resin system:
 - a. Compounded for fire retardancy and good dielectric characteristics.
 - b. Complying with UL 94 V E-1 (minimum) flammability rating.
- D. Exterior Finish:
 - 1. Polyester base material coating, 18 to 20 mils thick; Pleogen 2907 Iso-Gel, American Colors 66-20060, or approved equal.
 - 2. Color: Subject to approval of Engineer.
- E. Door and Hardware:
 - 1. Heavy duty, single hinged door.
 - 2. Swing: Capable of opening through minimum 180-degrees.
 - 3. Hardware material: Stainless steel.

4. Sealing gasket: Neoprene, memory-type, that ensures a tight seal.
 5. Latching mechanism:
 - a. Three-point door latching assembly (top, middle and bottom)
 - b. Handle: Lockable via pad lock.
 6. Hinge: Full length of door, 12 gauge minimum, concealed with door in closed position.
- F. Signage on Face of Enclosure:
1. Switch data nameplate complying with Section 26 05 00, Common Work Results for Electrical, Article titled "Identification."
 2. "Danger High Voltage" sign complying with Section 34 21 05, Common Work Results for Traction Electrification System (TES), Article titled "Warning Signs."

2.7 CABLE TERMINATIONS

- A. Line and load side terminals: Silver-plated copper bus, ASTM B187/B187M.
- B. Provide sufficient size bus to accommodate the number and size of dc power copper cables, entering from below or from above, as indicated.
- C. Cable lugs: NEMA terminal two-hole lugs.
- D. Clearance: Switch design shall provide a minimum 2-inches clearance from live parts to grounded parts after cables are terminated. Minimum clearance shall be maintained at all points of travel while the switch is being thrown.

2.8 SOURCE QUALITY CONTROL

- A. Switch assemblies shall be factory-assembled and precision aligned on base material and not be susceptible to distortion during installation.
- B. Factory Design Tests:
 1. Perform on one switch of each type to prove compliance with Specifications.
 2. Tests shall be conducted generally in accordance with those described in IEEE C37.34, including the following:
 - a. Dielectric tests.
 - b. Short time current test.
 - c. Temperature rise test.
 - d. Interrupting current test: Test and certify that switches are suitable for use on dc circuits with prospective fault current capabilities of 100 kA.
 3. Mechanical Tests:
 - a. Subject a sample switch and assembly to a maximum number of openings and closings to establish a life cycle capability.
 - b. Perform continuous and overload current-temperature tests before and after.
 - c. Perform inspection, using a feeler gauge (or other approved method), of each contact and assembly point.

- d. Acceptance criteria:
 - 1) Pass continuous and overload current-temperature tests.
 - 2) No gaps at contact or assembly points.
 - 3) Operating handle mechanism shall operate smoothly and easily.

C. Factory Production Tests:

- 1. Perform on each switch to check the quality and uniformity of workmanship and materials used.
- 2. Tests shall be conducted generally in accordance with those described in IEEE C37.34, including the following:
 - a. Operation of all components.
 - b. Power frequency dielectric withstand.
 - c. Electrical resistance of current path.
 - d. Insulation resistance and high-potential test.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install disconnect switches at the locations shown on the Contract Drawings.
- B. Verify adequacy of pole for supporting disconnect switch and accessories.
- C. Install in accordance with approved manufacturer's instructions.
- D. Provide mounting supports and additional hardware, as required, such as bolts, couplings, bushings, connectors, grounding conductors, and all basic electrical materials for a complete installation.
- E. Installation shall conform to NFPA 70.
- F. Operating Handle:
 - 1. Mount at 4 feet above grade or floor.
 - 2. Position operating mechanism so that handle does not intrude into the track clearance envelope and person operating switch will not be in danger from passing road vehicles or streetcars.
 - 3. Provide one padlock and two keys for each switch operating handle.
- G. Pole-Mounted Disconnect Switches:
 - 1. Mount each switch enclosure near the top of a taper tubular OCS pole or feeder pole equipped with feeder spouts, and provide with up to two surge arresters.
 - 2. Height and orientation of disconnect switch enclosure shall be agreed by the Engineer.
 - 3. At each disconnect switch, install a personnel ground mat as indicated on Contract Drawings.

H. Maintenance Shop Facility Disconnect Switches:

1. Wall mount with epoxy insulator standoffs.
2. Provide polycarbonate shroud as indicated on Contract Drawings.

3.2 CONNECTION OF CABLES

- A. Provide cable clamps on line and load side of switches to prevent stress on connectors and switch jaws.
- B. Orient bolts securing cable lugs such that they do not reduce the electrical clearance to grounded parts of the switch.

3.3 SUPERVISION OF SWITCH MANUFACTURER

- A. Install first switch under the direct supervision of a qualified representative of the switch manufacturer.
- B. Manufacturer's qualified representative shall certify that each switch is correctly installed and adjusted after installation and before initial energization.

3.4 ENERGIZATION

- A. Demonstrate to the satisfaction of the Engineer final switch positions and correct operation of each switch before energizing OCS.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 34 21 46 TRACTION POWER DC CONTACTOR PANEL

PART 1 - GENERAL

1.1 SUMMARY

- A. Contactor panel for Maintenance Shop Facility (MSF).
- B. Panel assembly includes dc contactors, fuses, relays, copper bus, control switches, and related components.

1.2 RELATED SECTIONS

- A. Section 05 05 00 – Common Work Results for Metals
- B. Section 26 05 19 – Low-Voltage Conductors and Cable
- C. Section 34 21 05 – Common Work Results for Traction Electrification System (TES)
- D. Section 34 21 80 – TES Spare Parts and Special Tools

1.3 REFERENCE STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents:
- B. ASTM International (ASTM)
 - 1. ASTM A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
 - 2. ASTM B187, Specification for Copper Bar, Bus Bar, Rod and Shapes
- C. International Electrotechnical Commission (IEC)
 - 1. IEC 60947-4-1, Low-Voltage Switchgear and Controlgear - Part 4-1: Contactors and Motor-Starters - Electromechanical Contactors and Motor-Starters

1.4 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Product Data:
 - 1. Submit manufacturers' product data for specified equipment and materials. Include the following information for each item:
 - a. Manufacturer's model number or item identification.
 - b. UL listing and rating.
 - c. Critical dimensions and mounting arrangement.
 - d. Replacement parts list.
- C. Spare Parts and Special Tools:
 - 1. Submit a list of spare parts to be provided under this Section.
 - 2. Submit at the same time as product data.

3. Provide part numbers for each part, including a detailed break down of each spare part assembly and set, as defined in Section 34 21 80, TES Spare Parts and Special Tools.
 4. Submit a list of special tools to be provided under this Section, as defined in Section 34 21 80, TES Spare Parts and Special Tools.
- D. Shop Drawings:
1. Submit shop drawings and electrical diagrams showing materials and methods of construction, door arrangement, contactors, fuses, and bus inside enclosure.
- E. Test Reports:
1. Submit copies of certified reports of factory and field tests performed in accordance with the applicable referenced standards and specification requirements.
- F. Operation and Maintenance Data:
1. Submit manufacturer's operating and maintenance instructions on products specified in this Section, including the following:
 - a. Description, including part number and manufacturer, of each type of contactor, fuse, relay, control switch, and related components.
 - b. Parts list, illustrations and diagram for components.
 - c. Wiring diagram.

1.5 SPARE PARTS

- A. Provide spare parts in accordance with Section 34 21 80, TES Spare Parts and Special Tools.
- B. List below applies to items in this Specification Section.
1. Dc contactor, OCS: Provide 1 spare.
 2. Dc contactor fuse: Provide 4 spare.
 3. Control switch: Provide 1 spare.
 4. Control fuse or mini-breaker: Provide 1 spare set.

1.6 QUALITY ASSURANCE

- A. Select a manufacturer who has been regularly engaged in the manufacture of similar equipment

PART 2 - PRODUCTS

2.1 DC CONTACTOR PANEL

- A. General Description:
1. Provide a single free-standing or wall mounted unit containing individual enclosed contactor sections connected by copper bus, as shown on Contract Drawings.
 2. Each contactor section includes fuses, relays, and related components for interlocking and control of Shop OCS.
 3. Refer to Contract Drawings for elevation and schematic drawings.
- B. Enclosure: NEMA 1, metal enclosed, minimum 12-gage steel, welded construction, ventilated, self supporting.

1. Fabricate from zinc-coated steel sheet conforming to ASTM A653/A653M, zinc coating designation G90.
 2. Reinforce with adequate steel framework to form a rigid structure with a smooth outer surface free from burrs, ridges and other blemishes.
 3. Doors: Hinged, minimum 14-gage steel.
 - a. Hinges: Stainless steel, full height.
 - b. Latches: Stainless steel, three-point.
 4. Finish: Powder coat in accordance with Section 05 05 00, Common Work Results for Metals.
 5. Color: In accordance with Section 05 05 00, Common Work Results for Metals.
- C. Dc Contactor:
1. Ratings:
 - a. Voltage: 1000 Vdc.
 - b. Current: OCS Contactor: 400 A continuous.
 2. Control Voltage: 125 Vdc.
 3. Auxiliary Contacts: Provide for interlocking.
- D. Fuses and Fuse Holders:
1. Fuses: Bolt-in, current-limiting type fuse for each OCS contactor.
 2. Fuse Holders: Rated 1000 Vdc.
 3. Size as shown on Contract Drawings.
- E. Bus Bars:
1. ASTM B187, 98 percent conductivity copper.
 2. Bolted bus connections, including bus taps and cable landing pads, shall be silver plated copper and joined with a minimum of two bolts and Belleville washers per joint.
 3. Each joint shall have conductivity at least equal to that of the bus bar and each joint shall be so clamped that no loss of conductivity will occur during the life of the panel.
 4. Mount bus bars on barrier-type insulation or post-type insulators of sufficient strength and braced to withstand, without damage or permanent distortion, stresses produced by the maximum available short-circuit currents.
- F. Control Wiring:
1. Factory-installed.
 2. Wire:
 - a. 2 kV switchboard wire complying with Section 26 05 19, Low-Voltage Conductors and Cable.
 - b. Minimum Size: No. 14 AWG.
 - c. For wiring across hinged joints: Class D stranded wire, minimum size No. 12 AWG.

3. Wire Terminals: Tinned copper ring compression terminals with insulated sleeve installed in accordance with the manufacturer's recommendations.
 4. Terminal Blocks: Provide washerhead screws suitable for ring compression terminals with insulated sleeve. Provide a minimum of ten percent spare terminals.
 5. Wire Connections: Make only on terminal blocks.
 6. Wire Identification:
 - a. Provide each wire with plastic heat shrink sleeve, attached within 6 inches of terminal connections and printed with the number indicated on the wiring diagrams.
 - b. Heat shrink sleeves after installation.
 7. Provide insulated barriers to separate control wiring from power wiring.
- G. LED Indication:
1. Provide panel mount LED lamps for indicating status of the contactor
 2. Red: Contactor closed
 3. Green: Contactor open

2.2 CONTACTOR CONTROL PANEL

- A. Provide wall-mounted control panels for controlling contactors connected to the OCS at each MSF bay, as shown in the Contract Drawings.
- B. Enclosure: NEMA 3X, metal enclosed, minimum 14-gage steel.
1. Fabricate from zinc-coated steel sheet conforming to ASTM A653/A653M, zinc coating designation G90.
 2. Doors: Hinged, minimum 14-gage steel.
 - a. Hinges: Stainless steel
 - b. Latches: Stainless steel, lockable.
 3. Finish: Powder coat in accordance with Section 05 05 00, Common Work Results for Metals.
 4. Color: In accordance with Section 05 05 00, Common Work Results for Metals.
- C. Control Wiring:
1. Factory-installed.
 2. Wire:
 - a. 2 kV switchboard wire complying with Section 26 05 19, Low-Voltage Conductors and Cable.
 - b. Minimum Size: No. 14 AWG.
 - c. For wiring across hinged joints: Class D stranded wire, minimum size No. 12 AWG.
 3. Wire Terminals: Tinned copper ring compression terminals with insulated sleeve installed in accordance with the manufacturer's recommendations.

4. Terminal Blocks: Provide washerhead screws suitable for ring compression terminals with insulated sleeve. Provide a minimum of ten percent spare terminals.
 5. Wire Connections: Make only on terminal blocks.
 6. Wire Identification:
 - a. Provide each wire with plastic heat shrink sleeve, attached within 6 inches of terminal connections and printed with the number indicated on the wiring diagrams.
 - b. Heat shrink sleeves after installation.
- D. Control switch:
1. Heavy duty, push button, rated for dc control voltage.
 2. Mechanism for padlocking in the open position: Heavy duty, steel.
 3. Provide a switch for both open and close operations.
- E. LED Indication:
1. Provide panel mount LED lamps for indicating status of the contactor.
 2. Red: Contactor closed.
 3. Green: Contactor open.

2.3 SIGNAGE

- A. Identification: Provide equipment and device nameplates on face of panel in accordance with Section 34 21 05, Common Work Results for Traction Electrification System (TES). See Contract Drawings for contactor numbering.
- B. Warning Signs: Provide 'DANGER HIGH VOLTAGE" signs on each section door that comply with Section 34 21 05, Common Work Results for Traction Electrification System (TES).

2.4 SOURCE QUALITY CONTROL

- A. In addition to the manufacturer's standard tests, as a minimum perform the following tests at the manufacturer's plant:
 1. Electrical operation tests.
 2. Control wiring checks.

PART 3 - EXECUTION

Not Used

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 34 21 50 DC SURGE ARRESTERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Product and installation requirements for dc surge arresters in traction power substations.
- B. Product requirements for dc surge arresters for OCS.

1.2 RELATED SECTIONS

- A. Section 26 05 19 – Low-Voltage Conductors and Cable
- B. Section 26 05 26 – Grounding and Bonding
- C. Section 34 21 80 – TES Spare Parts and Special Tools
- D. Section 34 21 90 – Traction Electrification System Testing
- E. Section 34 23 77 – OCS Surge Arrester Installation

1.3 REFERENCE STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents:
- B. American Society for Testing and Materials (ASTM)
 - 1. ASTM B3, Soft or Annealed Copper Wire
 - 2. ASTM B172, Rope-Lay Stranded Conductors having Bunch Stranded Members
- C. American National Standards Institute (ANSI)
 - 1. ANSI C62.11, Standard for Metal-Oxide Surge Arresters for Ac Power Circuits (> 1 kV)
- D. National Electrical Manufacturer's Association (NEMA)
 - 1. NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum)

1.4 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Product Data:
 - 1. Descriptive data on the surge arresters to be provided.
 - 2. Shop (installation) drawings to scale showing the surge arrester installation.
- C. Spare Parts and Special Tools:
 - 1. Submit a list of spare parts to be provided under this Section.
 - 2. Submit at the same time as product data.

3. Provide part numbers for each part, including a detailed break down of each spare part assembly and set, as defined in Section 34 21 80, TES Spare Parts and Special Tools.
 4. Submit a list of special tools to be provided under this Section, as defined in Section 34 21 80, TES Spare Parts and Special Tools.
- D. Submit factory test reports within 30 days after conducting tests:
1. Design test reports.
 2. Production test reports.

1.5 SPARE PARTS

- A. Provide spare parts in accordance with Section 34 21 80, TES Spare Parts and Special Tools.
- B. List below applies to items in this Specification Section.
1. Dc surge arrester, complete with mounting bracket and minimum 3-foot extra-flexible grounding conductor: Provide 10 spares.

1.6 QUALITY ASSURANCE

- A. Manufacturer's Qualifications:
1. Manufacturer shall have minimum 5 years of successful use of its surge arrester at light rail or street car facilities.
 2. Excessive failures of the proposed surge arrester at one or more transit facilities disqualifies the product for use on this project.

PART 2 - PRODUCTS

2.1 DC SURGE ARRESTERS

- A. Dc surge arresters shall be outdoor style, intermediate class and shall be designed, constructed, and tested in accordance with the general requirements of ANSI C62.11.
- B. Surge arresters shall be of the metal oxide varistor (MOV) type.
- C. MOV elements shall be fully encapsulated in epoxy.
- D. Minimum conduction voltage: 1000 V.
- E. Energy discharge capability: 2.6 kJ for currents 500 A or less.
- F. Reverse voltage across rectifier silicon diodes: Arresters shall limit to a value less than 75 percent of the peak-reverse-voltage rating of the diode by limiting the rise of the transient on the positive to negative bus.
- G. Acceptable Manufacturer/Supplier: Reuel/Balfour Beatty Rail, Inc., IMP-1, or approved equal.

2.2 GROUNDING CONDUCTOR

- A. Extra-flexible bare cable: Copper, 4/0 AWG, Class I stranding, ASTM B3, ASTM B172.
- B. Insulated cable: Copper, 4/0 AWG, 2 kV rated insulation. Refer to Section 26 05 19 Low-Voltage Conductors and Cable for requirements.
- C. Splice: C-type compression connector, Burndy Hyground or approved equal.

2.3 SOURCE QUALITY CONTROL

A. Design Testing:

1. Test to Failure:

- a. Perform test on one surge arrester.
- b. Install surge arrester in proposed enclosure, or in approved alternate mounting arrangement, complete with cables connected.
- c. Test to failure at two times energy rating and verify that arc clears and that enclosure does not fail catastrophically.
- d. If enclosure does not contain the surge arrester failure, submit a new surge arrester, new enclosure, or both, and retest.

B. Production Testing:

1. Energy Test:

- a. Test each surge arrester and provide test report.
- b. Test at 80 percent of rated energy.

2. Voltage Test (minimum requirement; additional tests may be performed):

- a. Test each surge arrester after completion of the energy test and provide test report.
- b. Test using a calibrated ac dielectric test set capable of reading leakage values.
- c. Apply 1000 Vac for 30 seconds. Maximum allowable leakage current 15 mA.
- d. Increase voltage to 1100 Vac for 5 seconds. Maximum allowable leakage current 30 mA.

2.4 SUBSTATION ASSEMBLY

A. Negative: Provide surge arresters connected between the negative bus and the ground mat.

B. Positive: Provide surge arresters between the load side of each dc feeder breaker and the ground mat as indicated in Contract Drawings.

C. Provide surge arresters in enclosures:

1. Wall mount enclosure on exterior of TPSS.
2. Mount enclosure, if metallic, on stand-off insulators.
3. Mounting Height: Above 8 feet to bottom of enclosure.

D. Install in accordance with surge arrester manufacturer's instructions.

E. Install conductors with a minimum number of bends. Bends shall be no less than 8-inch radius.

F. Connection of cable to surge arrester on ungrounded side shall be taped and covered with a heat-shrink insulating sleeve to provide an insulation level of 1000 V.

G. Ground side of surge arrester: Provide extra flexible grounding conductor, minimum length 3 feet.

1. Provide insulating grommet or cable connector where grounding conductor penetrates metallic enclosure to prevent grounding enclosure.

PART 3 - EXECUTION

3.1 SUBSTATION SURGE ARRESTERS

- A. Connect extra-flexible copper ground to ground-mat pigtail.
- B. If ground-mat pigtail is too short, provide cable and splices to connect ground-mat pigtail to substation surge arrester extra-flexible copper ground.

3.2 OCS SURGE ARRESTERS

- A. See Section 34 23 77, OCS Surge Arrester Installation, for installation requirements.

3.3 TESTING SURGE ARRESTER GROUNDS

- A. Test surge arrester grounds in accordance with Section 34 21 90, Traction Electrification System Testing.
- B. See required maximum values for grounds in Section 26 05 26, Grounding and Bonding.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 34 21 73 TE SYSTEM STUDIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Requirements for the following computer-based studies and reports for ac and dc switchgear associated with traction power substations:
 - 1. Short-circuit study.
 - 2. Ac coordination study.
 - 3. Dc coordination study.
 - 4. Arc-flash hazard analysis study.

1.2 REFERENCE STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents, or if standard is adopted by the City of El Paso, the latest revision adopted:
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. IEEE 241, Recommended Practice for Electric Power Systems in Commercial Buildings
 - 2. IEEE 242, Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
 - 3. IEEE 399, IEEE Recommended Practice for Power Systems Analysis
 - 4. IEEE 1015, Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems
 - 5. IEEE 1584, Guide for Arc Flash Hazard Calculations
 - 6. IEEE C37.20.1, Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
 - 7. IEEE C37.46, Standard Specifications for High Voltage (> 1000 V) Expulsion and Current-Limiting Type Power Class Fuses and Fuse Disconnecting Switches
 - 8. IEEE C57.96, Guide for Loading Dry-Type Distribution and Power Transformers
- C. American National Standards Institute (ANSI):
 - 1. ANSI Z535.4, Standard for Product Safety Signs and Labels
- D. Insulated Cable Engineers Association (ICEA)
 - 1. ICEA P-32-382, Short Circuit Characteristics of Insulated Cable
 - 2. ICEA P-45-482, Short-Circuit Performance of Metallic Shielding and Sheaths
- E. National Electrical Manufacturer's Association (NEMA)
 - 1. NEMA MG 1, Motors and Generators

F. National Fire Protection Association (NFPA)

1. NFPA 70, National Electrical Code (with City of El Paso amendments)

1.3 SUBMITTALS

1. Procedures: Section 01 33 00, Submittal Procedures.
2. Product Data: Computer software to be used for system simulation.
3. Product Certificates:
 - a. For short-circuit and overcurrent protective device coordination study, provide certification of compliance with IEEE 399.
 - b. For arc-flash hazard analysis, provide certification of compliance with IEEE 1584.
4. Qualifications: Submit names, contact information and qualifications including references for at least five short-circuit, coordination study and arc-flash calculations of comparable complexity within the last five years.
5. Provide the following reports for each substation:
 - a. Input data including completed computer program input data sheets.
 - b. Short-Circuit Study and Equipment Evaluation Reports.
 - c. Ac Coordination Study Report: Submit at the same time as Dc Coordination Study Report.
 - d. Dc Coordination Study Report.
 - e. Arc Flash Hazard Analysis Report.

1.4 QUALITY ASSURANCE

- A. Studies shall use computer programs that are distributed nationally and are in wide use.
 1. Software algorithms shall comply with requirements of standards and guides specified in this Section.
 2. Manual calculations or calculations using spreadsheet software are not acceptable.
- B. Study Specialist Qualifications:
 1. Analysis and reports shall be prepared by an individual experienced in the application of computer simulations to traction power systems.
 2. Qualifications shall be submitted for approval and shall document that the individual has at least five years experience and has prepared five studies of comparable complexity.
 3. Analysis and reports shall be supervised and signed by a professional electrical engineer licensed in the State of Texas.
- C. Studies, analysis, and reporting shall comply with the following standards:
 1. IEEE 241 and 242 for short-circuit and coordination analysis.
 2. IEEE 399 for general study procedures.
 3. IEEE 1584 and NFPA 70E for arc-flash hazard analysis.
 4. NFPA 70 (with City of El Paso amendments).

PART 2 - PRODUCTS

2.1 SIMULATION SOFTWARE

- A. Acceptable Software: Subject to approval, simulation software shall be the product of one of the following developers.
 - 1. CGI CYME
 - 2. EDSA Micro Corporation
 - 3. ESA Inc.
 - 4. Operation Technology, Inc.
 - 5. SKM Systems Analysis Inc.

2.2 SOFTWARE REQUIREMENTS

- A. Computer software for short-circuit study shall include analytical features described in IEEE 399 as Mandatory, Very Desirable, and Desirable.
- B. Computer software:
 - 1. Shall be capable of plotting and diagramming time-current characteristic curves as part of the output.
 - 2. Shall report device settings and ratings of all overcurrent protective devices.
 - 3. Shall demonstrate selective coordination by computer-generated, time-current coordination plots using different colors for each protective device.

PART 3 - EXECUTION

3.1 DATA COLLECTION AND COORDINATION

- A. Collect data from equipment suppliers, other contractors or subcontractors, El Paso Electric, and the Owner in order to complete the analysis.
- B. Coordinate required distribution equipment ratings and protective device settings to provide a fully-integrated distribution system that is properly coordinated and meets the requirements of NFPA 70. Proceed with final analysis only after relevant equipment has been finally determined and submittal information is sufficient to produce accurate simulation results.

3.2 SYSTEM DOCUMENTATION

- A. Collect and tabulate the following input data to support studies.
 - 1. Product data for overcurrent protective devices including devices furnished by others and involved in overcurrent protection.
 - 2. Resistance and reactance data and fault current data from serving utility.
 - 3. Electrical Distribution System Diagram. Provide documentation in both paper and electronic formats for the following:
 - a. Circuit breaker and fuse current ratings and types.
 - b. Relays and associated power and current transformer ratings and ratios.

- c. Transformer ratings including kVA ratings for each cooling type, primary and secondary voltages, connection type, transformer impedance, and X/R ratios. Provide information on transformer over-temperature sensors provided.
 - d. Cable information including number in parallel, conductor material, compaction, sizes, insulation type and temperature ratings, and cable length.
 - e. Busway material, ampacity, and impedance.
 - f. Motor horsepower, full-load current and code letter according to NEMA MG 1.
4. Equipment data sheets:
- a. Special load considerations including starting inrush currents and frequent starting.
 - b. Transformer characteristics, including primary protective device recommendations, inrush current, and thermal damage curve.
 - c. Motor full-load current, locked-rotor current, service factor, starting time, type of starter, and thermal damage curve.
 - d. Utility protective device types, ratings and relay settings.
 - e. Special overcurrent protective device settings or types if required by the serving utility.
 - f. Time-current characteristic curves of devices to be coordinated.
 - g. Circuit breaker manufacturer, frame size, interrupting capacity, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range.
 - h. Overcurrent relay manufacturer, type, ampere tap range, time-delay range, instantaneous range, and current transformer ratio.
 - i. Panelboard and switchboard, ampere rating and interrupting rating.
- B. Use equipment identification tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.

3.3 SHORT-CIRCUIT STUDY

- A. Calculate maximum available fault current in amperes rms symmetrical at overcurrent protective device positions throughout the electrical distribution system. Calculation shall be for current immediately after initiation of a three-phase bolted fault at each of the following:
 - 1. Switchgear and switchboard bus.
 - 2. Distribution panelboard.
 - 3. Branch circuit panelboard.
- B. Analyze the electrical distribution system from normal and alternate power sources throughout electrical distribution system. Include studies of system switching configurations and alternate operations that could result in maximum fault condition.
- C. Calculate momentary and interrupting duties on the basis of maximum available fault current.
- D. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with IEEE 241 and IEEE 242.
 - 1. For transformer, comply with IEEE C57.96.

2. For low-voltage circuit breakers, comply with IEEE 1015 and IEEE C37.20.1.
 3. For low-voltage fuses, comply with IEEE C37.46.
- E. Final Report
1. Indicate calculated X/R ratios and equipment (half-cycle) fault currents on electrical one-line diagram.
- F. Equipment Evaluation Report
1. 600V overcurrent protective devices: Ensure that interrupting ratings are equal to or higher than calculated available half-cycle symmetrical fault current.
 2. Devices and equipment rated for asymmetrical fault current: Apply multipliers listed in the Standards to half-cycle symmetrical fault current.
 3. Conductors:
 - a. Verify adequacy of phase conductors at maximum three-phase bolted fault currents.
 - b. Verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents.
 - c. Ensure that short-circuit withstand ratings are equal to or higher than calculated half-cycle symmetrical fault currents.

3.4 AC COORDINATION STUDY

- A. Perform coordination study using approved computer software. Prepare a written report using results of short-circuit study. Comply with IEEE 399.
1. Calculate the maximum and minimum half-cycle short-circuit currents.
 2. Calculate the maximum and minimum ground-fault currents.
- B. Comply with IEEE 241 and IEEE 242 recommendations for fault currents and time intervals.
- C. Transformer Primary Overcurrent Protective Devices:
1. Devices shall not operate in response to the following:
 - a. Transformer magnetizing inrush currents.
 - b. Self-cooled, full-load current or forced-air-cooled, full-load current, as appropriate. For transformer equipped for future fan cooling option, overcurrent protective devices shall be capable of resetting to the higher forced-air-cooled rating.
 - c. Permissible transformer overloads according to IEEE C57.96 if required by expected loading or emergency conditions.
- D. Conductor Protection:
1. Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242.
 2. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary protection or total clearing time of the fuse.
 3. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

- E. Coordination Study Report: Prepare a written report including the following:
1. A table with settings selected for overcurrent protective devices including:
 - a. Device identification tag.
 - b. Current transformer ratios and relay curve, tap, time-dial and instantaneous pickup settings.
 - c. Circuit breaker sensor rating and long-time, short-time and instantaneous trip settings.
 - d. Fuse type and current rating.
 - e. Ground-fault relay pickup and time-delay settings.
 2. Coordination Curves:
 - a. Provide documentation of settings of overcurrent protective devices to achieve selective coordination.
 - b. Provide time-current curves to graphically illustrate that adequate time separation exists between devices installed in series, including utility upstream devices.
 - c. Prepare separate sets of curves for the switching schemes and for emergency periods where the power is fed from an alternate source.
 - d. Include the following information:
 - 1) Device identification tag
 - 2) Time and current multipliers for curves.
 - 3) Three-phase and line-to-ground damage points for each transformer.
 - 4) No damage, melting, and clearing curves for fuses.
 - 5) Cable damage curves
 - 6) Transformer inrush points.
 - 7) Maximum fault-current cutoff point.
 3. Prepare and include in study completed data sheets for setting of overcurrent protective devices.
 4. Graphs shall be plotted in both distinctive colors and line styles for each time-current characteristic and damage curve so that black-and-white copies of graphs are still understandable.
 5. Provide both bound color copies and color electronic files in PDF format for report.

3.5 DC COORDINATION STUDY

- A. Include the following as a minimum:
1. Dc bolted positive to negative and positive to ground fault calculations.
 2. Protective device range and setting calculations showing basis for each recommended relay setting.
 3. Plots of rectifier design capability with actual margin of coordination (from breaker trip to design capability) clearly indicated at each of 100, 150 and 200 percent full-load current and short-circuit current.

3.6 ARC-FLASH HAZARD ANALYSIS

- A. Perform Arc-Flash Hazard Analysis with the aid of computer software intended for this purpose.
- B. Perform analysis in conjunction with short-circuit and coordination studies.
- C. Submit the results of the analysis in a table and include device or bus identification tag, bolted fault and arcing fault current levels, flash protection boundary, distances, personal-protective equipment classes and arc-flash incident energy (AFIE) levels.
- D. Perform the analysis under worst-case fault conditions, and describe in the final report when applicable, how these conditions differ from worst-case bolted fault conditions.
- E. Provide self-adhesive equipment labels in compliance with ANSI Z535.4 to document arc flash hazard and required personal protective equipment.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 34 21 80 TES SPARE PARTS AND SPECIAL TOOLS

PART 1 - GENERAL

1.1 SUMMARY

- A. Requirements for providing spare parts indicated in other Sections.
- B. Requirements for providing maintenance equipment.

1.2 DEFINITIONS

- A. Assembly: A unit consisting of components or parts that have been fitted together to form a self-contained device or fixture.
- B. Set: The quantity of the stated part that is provided as part of one substation. For example, if the part is "LEDs for Dc Switchgear," and 1 substation has 2 red LEDs, 2 green LEDs, and 1 white LED for Dc Switchgear, then 4 sets consists of 8 red LEDs, 8 green LEDs, and 4 white LEDs.

1.3 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Submit all items described below a minimum of 90 days before delivery of first spare parts:
 - 1. Comprehensive list of mandatory spare parts. Include spare parts listed in each section of these Specifications that contains a spare parts requirement. List by Specification section.
 - 2. Comprehensive list of mandatory special tools for each TPSS.
 - 3. List of additional recommended spare parts, special tools, and test and maintenance equipment. List separately the recommended special tools, test, and maintenance equipment that can be shared by substations.
 - 4. Provide part numbers for each part, including a detailed break-down of each spare part assembly and set.
 - 5. Provide a price for each part that can be purchased separately, effective for 1 year after notice to proceed.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Schedule: Delivery of spare parts shall be complete a minimum of 60 days before initial energization of the first segment of OCS.
- B. Notice and Shipping List: Provide Engineer notice of delivery and a complete shipping list a minimum of 10 days before delivery. Shipping list shall include the following:
 - 1. Quantity of each part.
 - 2. Manufacturer's part number.
 - 3. Serial number, if applicable.
 - 4. Description.
 - 5. Spaces for inserting date of delivery, signature of Contractor, and signature of Engineer.

- C. Authorization: Spare parts shall not be shipped until authorized by Engineer.
- D. Location: Deliver spare parts to a location in greater El Paso, Texas metropolitan area designated by the Engineer.
- E. Packaging: Package and label spare parts in moisture-proof containers suitable for shipment and storage. Attach copies of shipping list in the package and to the exterior of the package.
- F. Unloading: Unload spare parts in a manner that will prevent damage to the packages and the contents.
- G. Inspection:
 - 1. Engineer will open the packages and inspect spare parts for damage. Damaged parts will be returned to Contractor and shall be replaced with undamaged parts and materials at no additional expense to the Owner.
 - 2. Assist Engineer in verifying quantity of parts.
 - 3. Sign shipping list with quantities verified, obtain Engineer's signature, and date. Engineer will retain the signed shipping list.

PART 2 - PRODUCTS

2.1 REPLACEMENT PARTS

- A. Mandatory Spare Parts:
 - 1. Provide quantity and type of spares specified in each Specification Section. Supply of a spare from one Section does not satisfy the requirement for an identical spare specified in a different Section.
 - 2. Spare parts shall be identical to those submitted for approval and provided in substations.
 - 3. Unit price: Include on the submitted mandatory and recommended spare parts lists a price for each item that can be purchased separately, effective for 1 year after notice to proceed.
- B. Spare Parts for Warranty Repairs:
 - 1. The capital spare parts or the spare parts ordered by the Owner for support of operations are not to be used by the Contractor for warranty repairs and warranty parts replacements. Engineer will not be responsible for receiving or storing any parts for warranty support.
 - 2. At the end of the warranty period, the Owner may consider a negotiated price for purchase of parts stocked by the Contractor for warranty support.
- C. Availability of Replacement Parts:
 - 1. Guarantee parts availability for a period of 10 years from Contract award.
 - 2. Provide detailed manufacturing drawings to the Owner at the end of the 10-year period or when the availability of parts ceases after that date.

2.2 MANDATORY SPECIAL TOOLS

- A. Special tools include but are not limited to fixtures, equipment, gages, hand tools, power tools, motors, or other tools and equipment necessary to troubleshoot, maintain, repair, overhaul, assemble, disassemble, and adjust the TPSS and other elements of the traction electrification system that are not commonly available from commercial tool suppliers.
- B. Provide one set of special tools for each TPSS and one set for the traction electrification system.

2.3 RECOMMENDED SPARE PARTS AND SPECIAL TOOLS

- A. Provide list of recommended spare parts including description, break down, part number, recommended quantity, and unit price.
- B. Provide list of recommended special tools, test, and maintenance equipment. The Owner may or may not exercise purchase of the recommended items.

PART 3 - EXECUTION

Not Used

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 34 21 90 TRACTION ELECTRIFICATION SYSTEM TESTING

PART 1 - GENERAL

1.1 SUMMARY

- A. General testing requirements.
- B. Factory Acceptance Testing traction electrification substation and its components.
- C. Field Acceptance Testing traction electrification substation and its components.
- D. Field testing traction electrification system.
- E. Other test requirements appear in other Sections.
- F. The requirements of this Section apply to all Division 26 and Division 34 21 xx Sections.

1.2 RELATED SECTIONS

- A. Section 26 50 00 – Lighting
- B. Section 34 21 23 – Transformer-Rectifier Unit
- C. Section 34 21 25 – TPSS Dc Control Power
- D. Section 34 21 31 – Substation Automation System (SAS)
- E. Section 34 21 33 – Rail Voltage Monitoring and Grounding System

1.3 REFERENCE STANDARDS

- A. Section incorporates by reference the latest revisions of the following documents:
- B. American National Standards Institute (ANSI)
 - 1. ANSI C39.1, Requirements for Electrical Analog Indicating Instruments
- C. Institute of Electrical and Electronics Engineers (IEEE)
 - 1. IEEE 80, IEEE Guide for Safety in Ac Substation Grounding
 - 2. IEEE 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
 - 3. IEEE 400, Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems
 - 4. IEEE 1106, Recommended Practice for Installation, Maintenance, Testing, and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications
 - 5. IEEE 1653.2, Standard for Uncontrolled Traction Power Rectifiers for Substation Applications Up to 1500 Vdc Nominal Output
 - 6. IEEE C37.14, Standard for Low-Voltage Dc Power Circuit Breakers Used in Enclosures
 - 7. IEEE 37.20.1, Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
 - 8. IEEE C37.34, Standard Test Code for High-Voltage Air Switches

9. IEEE C37.41, Standard Design Tests for High-Voltage (> 1000 V) Fuses, Fuse and Disconnecting Cutouts, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories Used with These Devices
 10. IEEE C37.90, Standard for Relays and Relay Systems Associated With Electric Power Apparatus
 11. IEEE C57.12.91, Standard Test Code for Dry-Type Distribution and Power Transformers
 12. IEEE C57.13, Standard Requirements for Instrument Transformers
 13. IEEE C57.18.10, Standard Practices and Requirements for Semiconductor Power Rectifier Transformers
 14. IEEE C62.11, Standard for Metal Oxide Surge Arresters for Ac Power Circuits
- D. InterNational Electrical Testing Association (NETA)
1. NETA ATS, Acceptance Testing Specifications for Electric Power Distribution Equipment and Systems
- E. National Electrical Manufacturers Association (NEMA)
1. NEMA PE 5, Utility-Type Battery Chargers

1.4 FAILURE OF TEST

- A. If any test fails, make corrections and retest at no additional cost to the Owner.
- B. If off-site test is witnessed by Engineer or his representatives and fails, Contractor shall pay for return trip to facility or test site(s) including air fare and lodging.
- C. In the event equipment is not ready for testing by Contractor upon agreed testing date and Engineer or his representatives arrive at test site, Contractor shall pay for return air fare and lodging of Engineer or his representatives.

1.5 SUBMITTALS

- A. Procedures: Section 01 33 00, Submittal Procedures.
- B. Test program plan: Submit within 120 Days after NTP and provide monthly updates.
- C. Test procedures:
 1. Submit a minimum of 60 Days before test is scheduled to be performed.
 2. Tests shall not be performed and test reports will not be considered valid until procedures are approved by Engineer.
- D. Test reports:
 1. Submit within 30 calendar days after completion of each test unless otherwise indicated.
 2. Factory Design Test Reports:
 - a. Submit existing test reports 90 calendar days before shipping equipment. Equipment shall not be shipped until the report is approved by the Engineer.
 3. Factory Production Test Reports: For each test specified in other sections or indicated in this Section.
 4. Submit Electrically Insulated Floor and Wall Test Report for each substation before installing substation equipment:

5. Wire and cable testing report:
6. Cable insulation test for dc feeder cables. Traction Power Substation Factory Acceptance Test Report
7. Traction Power Substation Field Acceptance Test Reports. Pretest Traction Power Substation Factory Acceptance Test Report
8. Pretest Traction Power Substation Field Acceptance Test Report
9. Integrated Testing Test Reports:
 - a. Rail Voltage Monitoring and Grounding Devices Tests.
 - 1) Initial chart recording.
 - 2) Final record chart recording.
 - b. Short Circuit Test.
 - c. Train Start Tests.

1.6 REQUIREMENTS FOR TEST PROGRAM PLAN, TEST PROCEDURES, AND TEST REPORTS

A. Test Program Plan:

1. Identify each test by reference to the Section, Article, and Paragraph number of the appropriate Technical Section of these Specifications.
2. Provide a detailed schedule showing the time and place of each test to be performed.
3. Tests to be included:
 - a. Each test described in this Section and in other Contract Specification Sections, including a test for each substation equipment type or assembly.
 - b. Supplier and Subcontractor tests to be completed at the suppliers' or Subcontractors' plants.
 - c. Contractor's tests to be completed at its plant or approved independent testing lab prior to delivery.
 - d. Other tests conducted by Contractor in connection with its own Quality Assurance program.

B. Test Procedures: Develop detailed test procedures for each test containing the following:

1. Title of test.
2. Contract Specifications Section, Article, and Paragraph number.
3. Test location.
4. Name of the agency performing each test (Contractor, its supplier, or an independent testing company).
5. Test objective.
6. Equipment and instrumentation requirements including manufacturer's name, model number, and serial number.
7. Personnel requirements.

8. Attached copies of applicable portions of ANSI, IEEE, or NEMA standards. Obtain permission of copyright holder to reproduce the necessary portions of standards and pay copyright holder if required.
9. Test methodology including test setup, with circuit diagrams and test sequence.
10. A step-by-step procedure for performing the test, including all steps required for each device tested, even if devices are identical. For example, if there are four circuit breakers to test, provide a separate step-by-step procedure for each breaker.
11. Forms for recording test data:
 - a. May be incorporated into step-by-step procedure.
 - b. Include space for test equipment calibration data.
 - c. Include a step-by-step format for data reduction and formulas used in deriving the format.
 - d. Include criteria for acceptability and justification for the criteria set forth, including procedures for evaluating data.
 - e. Include space for signatures of test witnesses.
12. Expected test results.
13. Test evaluation procedures.
14. Proposed test report form.

C. Test Reports:

1. Each test report shall have attached the related and approved test procedure.
2. Each report shall document the test results obtained and shall include the following information:
 - a. Title of test.
 - b. Contract Specifications Section and Article number.
 - c. Test objectives.
 - d. Summary and conclusions including Pass/Fail or N/A.
 - e. Test location, date, and time.
 - f. List of test equipment used, including the following for each piece of test equipment:
 - 1) Manufacturer's name.
 - 2) Model number.
 - 3) Serial number.
 - 4) Calibration certificate showing that instrument was calibrated by an independent agency within the previous 12 months.
 - g. Conditions of test, including temperature and humidity.
 - h. Raw test data from the approved test procedure forms.
 - i. Reduced test data including tables, curves, photographs and any additional test data required to support the test results.

- j. Test results in a form that can easily be compared to these Specifications requirements.
- k. Descriptions of equipment and material failures, and reasons for the failure.
- l. Descriptions of all modifications to equipment or wiring performed during testing, reasons for modifications, and names of individuals approving such modifications.
- m. Abbreviations and references.
- n. Signatures of tester and test witnesses.

1.7 WITNESSING OF TESTS

- A. Engineer will, at his/her option, witness all tests.
- B. Testing Notification: At least 30 calendar days before each test, upon the approval of test procedure, notify Engineer in writing of the date, time, and location the test will be performed.
- C. If Engineer elects not to witness a test or tests, test reports shall nevertheless be submitted to Engineer for review and approval.
- D. Witnessing of test by Engineer shall not waive requirements in Specifications or relieve Contractor from its responsibility to produce test report in accordance with Specifications.

1.8 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Field testing of insulated power cables rated 2 kV and higher:
 - a. Shall be performed by a NETA certified technician working for an independent testing company under the direct supervision of Contractor.
 - b. NETA technician shall have at least 5 years experience in construction acceptance testing.
 - c. Testing company shall be a NETA member and approved by Engineer.
 - 2. Field acceptance testing of each substation shall be performed under direct supervision of Traction Power Installation Supervisor representing the manufacturer of the substation equipment.
 - 3. Testing Company: Tests shall be performed by the manufacturer, or a company or agency employed by Contractor with all of the following qualifications:
 - a. Approved by Engineer: Once such a company or agency is approved they shall not be discharged or otherwise replaced by Contractor without written approval of Engineer.
 - b. Employees assigned to the project shall be personnel familiar with electrical testing procedures, electrical instrumentation, and general electrical networks.
 - c. Personnel must be capable of modifying the specified procedures to suit actual field conditions should such modifications become necessary.

1.9 TEST CLASSIFICATIONS

A. Factory Design Tests:

1. Shall be conducted by or under supervision of the equipment manufacturer.
2. Shall demonstrate compliance with specified design requirements.
3. Shall be performed on production components, assemblies, subsystems and substations and shall be performed on the highest level of assembly that will allow demonstration of design compliance.
4. Limited to the number of units needed to demonstrate design compliance, typically one or two.

B. Factory Production Tests:

1. Shall be conducted by or under the supervision of the equipment manufacturer.
2. Shall demonstrate that each unit to be delivered operates within specified limits and is in compliance with design requirements and industry standards.
3. Test requirements may vary from an inspection and functional demonstration for a simple component to a full system functional demonstration of an assembly.
4. Perform tests of completely assembled substation at substation manufacturer's facility before shipping substation to site.
5. Perform at ambient conditions unless a specific environmental or operating limit is necessary to demonstrate acceptable operation.
6. For substations include the following:
 - a. Substation equipment and ancillary systems including control power for each substation.
 - b. Factory installed power and control cable and wire.

C. Factory Acceptance Tests:

1. Shall demonstrate that each substation or other equipment is complete and ready for shipping to the site, both functionally and cosmetically.

D. Field Acceptance Tests:

1. Shall demonstrate that each substation, cable installation, or other equipment is ready for energization and revenue service, both functionally and cosmetically.

E. Integrated systems testing:

1. Perform in cooperation with other contracts to demonstrate the proper function of the traction electrification system (TES).
2. Shall demonstrate that all interfaces are correct and operable.

1.10 QUALITY OF TEST DATA

A. Test Readings:

1. Take a sufficient number of readings to assure that random factors due to human error in reading the instruments and transient disturbances in electrical network have negligible influence on final results.
2. Establish adequacy of the data as follows:
 - a. Examine data to verify that removal of either the highest or lowest value will not alter the arithmetic average of the group by more than 5 percent.
 - b. If the average would be altered by more than 5 percent, take one more set of data and combine results with the first set.
 - c. If the average of the combined data would still be altered by more than 5 percent if the highest or lowest value were removed, advise Engineer that an unstable condition might exist.

PART 2 - PRODUCTS

2.1 TEST INSTRUMENTS

A. Electrical Megohmmeter for Insulation Testing:

1. 1000 Vdc output voltage suitable for resistance measurement from 500 kilohm to 500,000 megohms. Use a megohmmeter with an internal bleeder resistor for discharge.
2. Approved Manufacturer: Hipotronics or approved equal.

B. High-Potential Test Set:

1. Portable high-potential dc test set, 0 to 130 kVdc, 10 mA with regulated output.
2. Internal shorting solenoid and discharge resistor.
3. Full-scale accuracy: 2 percent.
4. Capable of measuring cable insulation resistance up to 5,000,000 megohms.
5. Approved Manufacturer: Hipotronics or approved equal.

2.2 SOURCE QUALITY CONTROL

A. Factory Design Tests:

1. Perform Factory Design Tests as specified in each Division 26 Section and 34 21 xx Section, under the Part 2 section titled "Source Quality Control."
2. Unless otherwise specified, if design tests have already been performed by the manufacturer of equipment, existing test reports may be submitted to Engineer, who will determine whether the new design test may be waived.
3. Existing test reports need not meet the format requirements specified in this Section. However, content of reports shall include all relevant information.
4. In the event components have not been design tested, tests shall be run on the first production unit and performed in accordance with these Specifications.

B. Factory Production Tests:

1. Perform Factory Production Tests as specified in each Division 26 Section and 34 21 xx Section, under the Part 2 section titled "Source Quality Control."

C. Electrically Insulated Floor and Wall Tests:

1. Perform hi-potential dielectric tests on the epoxy floor and wall insulation installed in each traction power substation enclosure prior to the installation of substation equipment.
2. Provide a hi-potential tester with a voltage range of 0-15,000 Vdc and a current range of 0-2000 microamperes dc to perform the tests.
3. Floor: Perform a wet mop test as follows:
 - a. Provide a sponge mop with a non-metallic handle. Provide a copper plate behind the sponge with a wire terminal to attach the test lead.
 - b. Connect one lead from the tester to the copper disk and the other lead to the station ac ground bus.
 - c. Apply 4500 Vdc from the hi-potential tester, using precautions such as insulated boots and hot gloves to protect the test technician.
 - d. Saturate the mop with saline solution of 1/3 salt and 2/3 water (by volume).
 - e. Mop the entire insulated floor with the room darkened. Re-saturate the mop as necessary.
 - f. Visible arcing indicates inadequate dielectric strength of the epoxy coatings; apply additional layers of epoxy until the leakage current is lower than 50 microamperes.
4. Walls: Perform a copper disk test as follows:
 - a. Provide a copper disc 4 inches in diameter and 1/4-inch thick. The disk shall have a non-conductive handle and wire terminal to attach the test lead.
 - b. Connect one lead from the tester to the copper disk and the other lead to the station ground bus.
 - c. Place the copper disc on the wall insulation at a minimum of 10 locations selected by Engineer where the laminate is fastened to the wall with mechanical fasteners.
 - d. Apply 4500 Vdc for 120 seconds and record the leakage current.
 - e. If leakage current is greater than 50 microamperes, epoxy insulation shall be applied to the fastener to increase the insulation and the fastener retested.

D. TPSS Factory Acceptance Test:

1. Pretest each substation using an approved test procedure and submit a test report prior to performing the factory acceptance test for witnessing.
2. Wire and Cable Testing:
 - a. Perform tests after factory or field wiring has been pulled in place and terminations installed.
 - b. Inspect wire and cable for physical damage and proper connections.
 - c. Protect semiconductor devices against the test voltage by means of shorting jumpers or other methods accepted by Engineer, if they are not inherently protected by the circuit in which they are used.

- d. Continuity Tests: Check continuity from point to point and check for shorts to ground with an ohmmeter.
 - e. Insulation Resistance Tests:
 - 1) Measure insulation resistance with a 1000 Vdc megohmmeter.
 - 2) Measure insulation resistance between conductor and ground.
 - 3) Test cables after terminations are complete. Do not connect equipment to the cable system during tests.
 - 4) Acceptance Criteria for 600 V wire and cable: 10 Megohms for 1,000 feet when measured at 25 C.
 - 5) Test Failure: If insulation resistance values are unacceptable, correct deficiency and retest. If the test fails again, replace the entire wire or cable segment.
 - f. High Potential Tests: In accordance with IEEE 400.
 - 1) Passing Criteria: No insulation breakdown or excessive leakage current.
 - 2) Failures: Locate and determine the trouble, replace defective wires, cables or components, make necessary corrections to installation, and retest without additional cost to the Owner.
 - g. Control circuit wiring: Test for continuity and insulation after termination.
 - h. Power and equipment branch circuits: Perform continuity test on conductors.
 - i. Three-phase loads: Verify circuit phasing.
3. Low-Voltage Panelboards and Enclosed Circuit Breakers:
- a. Test circuits for connections in accordance with the wiring diagram.
 - b. Test that insulation resistance to ground of nongrounded conductors is a minimum of 10 megohms.
 - c. Test panelboard and load center enclosures for continuity to the grounding system.
 - d. Test operation of circuits and controls. When testing, operate each control a minimum of 10 times and each circuit continuously for a minimum of 1/2 hour.
 - e. Test that each panel has a balanced load.
4. Ancillary Systems:
- a. Perform operational and functional tests on auxiliary and ancillary systems including the following:
 - 1) Auxiliary panelboards;
 - 2) Auxiliary contacts;
 - 3) Door interlocks;
 - 4) Receptacles;
 - 5) Interior, exterior, emergency, and cubicle lighting. Measure lighting levels and confirm that minimum lighting levels are met as required by Section 26 50 00, Lighting;

- 6) HVAC; and
 - 7) All systems provided in this Contract that are not specifically called out in this Section.
5. General Substation Operation:
- a. Perform a functional test of substation operation.
 - b. Check the interlocks on the enclosure and panels for proper functioning alarm and operation of shutdown circuitry.
 - c. Use strip chart recorders or oscillographs as required to provide a permanent record of the protective functions.
 - d. Perform other tests as required by substation equipment manufacturer and Engineer to determine the acceptability of the installation and equipment.
6. Ac Switchboard:
- a. Verify that circuits are connected in accordance with the applicable wiring diagrams.
 - b. Verify that circuits are continuous and free from short circuits.
 - c. Verify that the insulation resistance to ground of non-grounded conductors is megger tested to not less than 10 megohms.
 - d. Verify that circuits are operable. Conduct tests to include operating each control not less than ten times and the continuous operation of each lighting and power circuit for not less than 1/2 hour.
7. Dc Switchgear:
- a. High-potential tests:
 - 1) Disconnect high-resistance ground relay, Device 64, for this test.
 - 2) Perform test between the ac and dc switchgear, including fasteners and the isolation laminate, at 2500V dc. Leakage current shall be less than 50 microamperes.
 - 3) Perform test from dc switchgear enclosure to ground at 2500 Vdc. Leakage current shall be less than 50 microamperes.
 - 4) Perform continuity tests on all interconnecting cables and buses.
 - 5) Perform insulation test on all interconnecting feeder cables using a 2500 Vdc megohmmeter for 1 minute.
 - 6) Test positive and negative feeder buses to ground using a 2500 Vdc megohmmeter for 1 minute.
 - 7) Verify load measuring and reclosing functions.
 - b. Perform functional tests of the emergency trip stations (ETS).
 - c. Verify proper operation of all interlocks and Kirk key schemes.

8. Dc Relays:
 - a. Verify proper operation and setting of all relays including rate of rise, frame fault relay and rail to earth relay.
 - b. Where applicable, settings to be in accordance with approved relay coordination curves.
9. Traction Power Transformer:
 - a. Perform insulation tests between windings and between windings to ground and between the core to ground using a 2500 Vdc megohmmeter for 1 minute.
 - b. Perform functional tests of temperature protective devices.
10. Rectifiers:
 - a. Perform insulation tests between the diode strings and rectifier enclosure using a 2500 Vdc megohmmeter for one minute.
 - b. Perform insulation tests between the enclosure and ground using a 2500 Vdc ohmmeter for 1 minute.
 - c. Perform a functional test of all temperature, protective, monitoring and alarm devices.
11. Emergency trip stations (ETS): Perform functional test.
12. Substation Automation System (SAS):
 - a. Simulate alarm and analog functions at each device on Alarm Points List in Section 34 21 31, Substation Automation System (SAS).
 - 1) Simulation shall replicate actual field activation of functions to the extent possible.
 - 2) Include method of simulation of functions in test procedure for approval by the Engineer.
 - b. Demonstrate downloading of event log to flash drive or laptop.
13. SCADA:
 - a. Simulate alarm functions at each device on Alarm Points List in Section 34 21 31, Substation Automation System (SAS).
14. Transfer Trip: Simulate transfer trip and verify correct outputs at PLC for transfer trip.
15. Frame Fault (Device 64HS & GS) Tests:
 - a. Connection: As shown in the one-line diagram.
 - b. Test: Simulate a 750 Vdc to frame fault by passing low dc current levels through the relays.
 - c. Approval: Provide graphical outputs, including time-current characteristics, onsite at the time of testing for review and approval.
 - d. Criteria: Maximum total clearing time including operation of the 64HS & GS relay, the substation lock-out relay, and the tripping of the main ac and dc feeder breakers shall not exceed 300 ms.

16. Rail Voltage Monitoring and Grounding Devices Tests:

- a. Test: Demonstrate proper function of the rail-to-earth relay and rail-to-earth grounding device.
 - 1) Simulate rail-to-earth voltages and currents.
 - 2) Show that the substation will alarm, trip, and short circuit rail to earth when the voltage and currents exceed the alarm, trip, and short circuit points specified in Section 34 21 33, Rail Voltage Monitoring and Grounding System.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. TPSS Field Acceptance Test:

- 1. General Requirements:
 - a. Perform tests in accordance with NETA Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
 - b. Perform after complete installation of each traction power substation.
 - c. Verify that all equipment is properly installed in accordance with approved drawings, in operable condition and all open inspection items and NCRs have been corrected. Pretest traction power substation prior to witness testing.
 - d. No equipment shall be energized or placed in operating mode until completion of Field Acceptance Testing and permission of Engineer.
- 2. Wire and Cable Testing:
 - a. Retest wire and cable after delivery of substation in accordance with Paragraph above titled Factory Acceptance Test.
- 3. Electrically Insulated Floor and Wall Tests:
 - a. Repeat factory tests on wall and floor areas not covered by installed switchgear.
 - b. Verify that insulated floor and walls have not been damaged in shipping.
- 4. General Substation Operation:
 - a. Perform a functional test of substation operation before energizing the substation. Energize only circuits 600V or less for functional test.
 - b. Include steps specified above in Part 2 under Paragraph titled "Factory Acceptance Test" and Sub-paragraph titled "General Substation Operation."
- 5. Dc Switchgear:
 - a. High-potential tests: Repeat these tests as specified above in Part 2 under Paragraph titled "Factory Acceptance Test."
 - b. Verify proper operation of all interlocks and Kirk key schemes.

6. Dc Relays:
 - a. Verify proper operation and setting of all relays including rate of rise, frame fault relay and rail to earth relay.
 - b. Where applicable, settings to be in accordance with approved relay coordination curves.
7. Transformer-Rectifier Unit:
 - a. Perform audible sound test inside substation with HVAC system turned off, in accordance with requirements of Section 34 21 23, Transformer-Rectifier Unit.
8. Traction Power Transformer:
 - a. Perform insulation tests between windings and between windings to ground and between the core to ground using a 2500 Vdc megohmmeter for 1 minute.
 - 1) Pass/fail criteria: Test is passed if megohmmeter is able to hold the specified voltage for 1 minute.
 - b. Perform functional tests of temperature protective devices.
9. Rectifiers:
 - a. Perform insulation tests between the diode strings and rectifier enclosure using a 2500 Vdc megohmmeter for one minute.
 - 1) Pass/fail criteria: Test is passed if megohmmeter is able to hold the specified voltage for 1 minute.
 - b. Perform insulation tests between the enclosure and ground using a 2500 Vdc ohmmeter for 1 minute.
 - 1) Pass/fail criteria: Test is passed if megohmmeter is able to hold the specified voltage for 1 minute.
 - c. Perform a functional test of all temperature, protective, monitoring and alarm devices.
10. Emergency trip stations (ETS): Perform functional test.
11. Substation Automation System:
 - a. Repeat tests specified above in Part 2 under Paragraph titled "Factory Acceptance Test."
 - b. Demonstrate with actual field activation of functions to the extent possible.
12. SCADA: Repeat tests specified above in Part 2 under Paragraph titled "Factory Acceptance Test."
13. Transfer Trip: Simulate transfer trip and verify correct outputs at PLC for transfer trip.
14. Frame Fault (Device 64HS & GS) Tests:
 - a. Connection: As shown in the one-line diagram.
 - b. Test: Simulate a 750 Vdc to frame fault by passing low dc current levels through the relays.
 - c. Approval: Provide graphical outputs, including time-current characteristics, onsite at the time of testing for review and approval.

- d. Criteria: Maximum total clearing time including operation of the 64HS & GS relay, the substation lock-out relay, and the tripping of the main ac and dc feeder breakers shall not exceed 300 ms.
 - e. Field adjustments: In the event that certain test conditions do not conform to the test procedure, make necessary field adjustments, perform necessary calculations to demonstrate successful test completion, present the calculation method to Engineer for review, and include with the test report.
15. Rail Voltage Monitoring and Grounding Devices Tests:
- a. Test: Demonstrate proper function of the rail-to-earth relay and rail-to-earth grounding device.
 - 1) Simulate rail-to-earth voltages and currents.
 - 2) Show that the substation will alarm, trip, and short circuit rail to earth when the voltage and currents exceed the alarm, trip, and short circuit points specified in Section 34 21 33, Rail Voltage Monitoring and Grounding System.
16. Battery:
- a. Perform after substation equipment has been installed onsite.
 - b. Perform acceptance tests in accordance with IEEE 1106.
 - c. Perform load test demonstrating that batteries comply with the requirements in Section 34 21 25, TPSS Dc Control Power, by duplicating the conditions stated under Battery Duty Cycle section.
17. Battery Charger:
- a. Perform after substation equipment has been installed onsite.
 - b. Perform in accordance with NEMA PE 5.
18. Ancillary Systems:
- a. Repeat tests specified in Part 2, above under the Paragraph titled "TPSS Factory Acceptance Test."
19. Power Meter:
- a. Testing shall be performed by a qualified testing agency using calibrated reference standard devices.
 - 1) The test instruments shall be calibrated and traceable to the National Institute of Standards and Technology (NIST).
 - 2) Calibrate analog instruments no more than 6 months prior to testing.
 - 3) Calibrate digital instruments no more than 12 months prior to the test.
 - 4) Provide certificates of calibration for the reference standard devices.
 - b. Test for accuracy of the following:
 - 1) Four-quadrant energy measurement accuracy: KWh imported, kWh exported, kWh net, kVARh imported, kVARh exported, kVARh net, kVAh imported, kVAh exported, kVAh net.

- 2) Power measurement accuracy including active, reactive and apparent (kW, kVAR and kVA).
- 3) Demand Accuracy.
- 4) L-L and L-N voltage measurement accuracy of every phase.
- 5) Current measurement accuracy of every phase.
- 6) Power Factor.
- 7) Frequency.
- 8) CT accuracy test (10 percent, 20 percent, 30 percent, 40 percent, 50 percent through rated current, including ratio test), CT phase error test, PT accuracy test (including ratio test), burden test of CT circuit.

c. Verify metering transformer configuration and wiring match the power meter configuration, CT/PT polarities are correct and CT/PT ratios are correct.

B. Traction Power Cable Testing and Inspection:

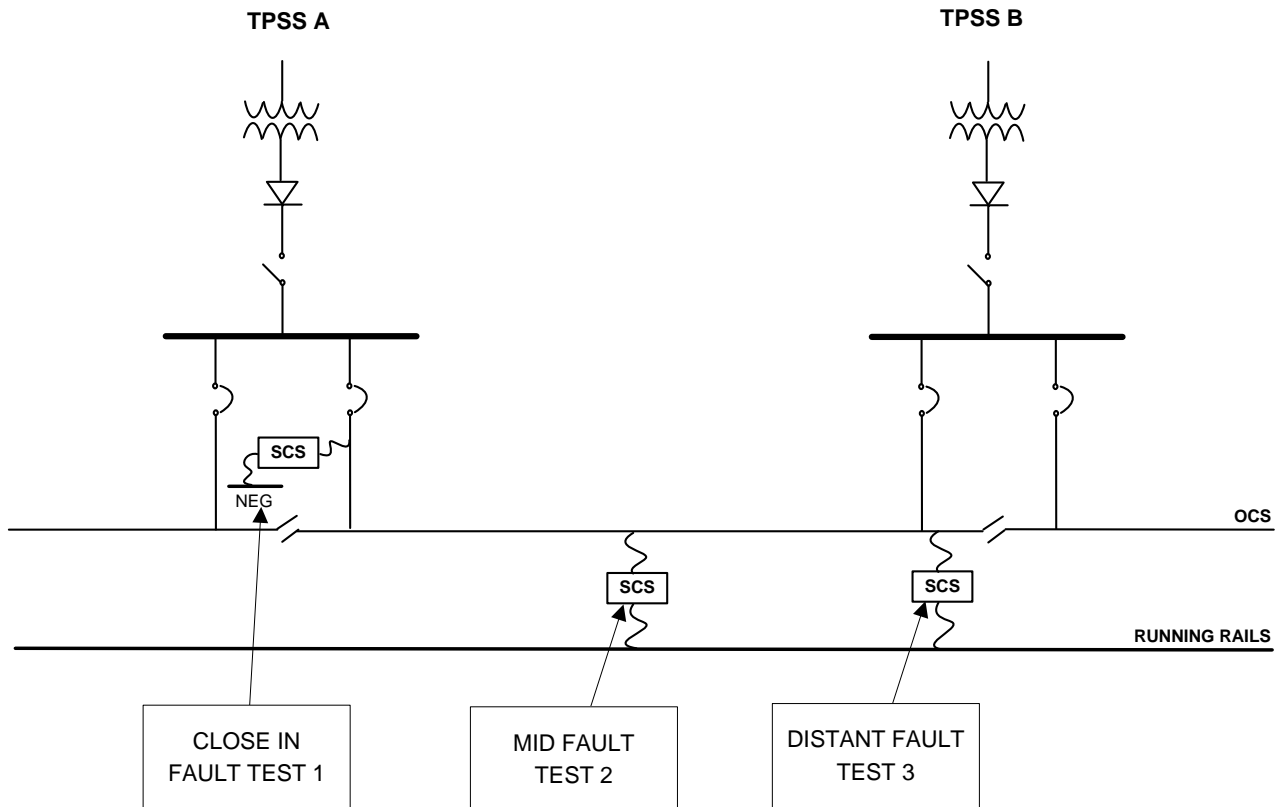
1. Before connecting cables to rails or OCS, perform dc insulation-resistance test in accordance with NETA ATS Section 7.3.3, Cables, Medium- and High-Voltage, using a dc high-potential test set.
2. Perform visual and mechanical inspection of cable in accordance with NETA ATS Section 7.3.3.

C. Traction Power Substation Energization Testing:

1. Obtain permission from Engineer before energizing substation.
2. Traction Power Transformers:
 - a. Adjust transformer taps for optimum dc output voltage based on ac service voltage at each location.

D. Short Circuit Test:

Diagram for Close in, Mid, and Distant Fault Tests



1. Close in Fault Test.

- a. Purpose: This test is performed to determine system I_{max} and adjust protection relay settings.
- b. Preparation:
 - 1) Disable the automatic tripping elements of the dc breakers during this test in order to obtain data of actual fault current levels.
 - 2) Place a jumper across line and load terminals of the feeder breaker and move to the connected position.
 - 3) Energize only TPSS A. The adjacent substations are de-energized.
- c. Test: Using a short circuit switch (SCS) apply a bolted fault from line side of the dc feeder breaker to the negative bus.
- d. After Test: Verify that the dc breaker trips according to protection coordination study.

2. Mid Fault Test:

- a. Purpose: This test is performed to determine the system resistance and inductance profile and adjust protection relay settings.
- b. Preparation:
 - 1) Disable the automatic tripping elements of the dc feeder breakers.

- 2) Energize only TPSS A. The adjacent substations are de-energized.
 - c. Test: Using a short circuit switch (SCS) apply a bolted fault from messenger wire to rail at a distance from TPSS B to be provided by the Engineer.
 - d. After Test: Verify and apply new protective settings if necessary.
 - e. Re-test: Repeat Mid Fault Test with new settings to verify that the breaker trips according to new protection setting.
 - 3. Distant Fault Test:
 - a. Purpose: This test is to verify that the dc protection relay will detect a fault at the furthest point from the substation under test and adjust protection relay settings.
 - b. Energize only TPSS A. The adjacent substations are de-energized.
 - c. Test: Using a short circuit switch (SCS) apply a bolted fault from OCS to rail at the location furthest from the feed point of the substation under test.
 - d. After Test: Verify that the dc breaker trips according to protection coordination study.
- E. Integrated Testing:
- 1. The Contractor shall develop the test procedures and test forms for these tests. These test procedures and forms shall be submitted for review and approval. The results from the tests will be used to set the Rail Voltage Monitoring and Breaker Relay settings. These test shall be coordinated with the Owner with respect to scheduling the operators and street cars to perform the tests. The Owner will provide the available dates and streetcars. .
 - 2. Rail Voltage Monitoring and Grounding Devices Tests:
 - a. Initial Chart Recording:
 - 1) For each substation, provide a 48-hour chart recording of the rail-to-earth voltages and currents measured at the terminals of the negative cubicle during simulated revenue service.
 - 2) Set horizontal and vertical scale such that both time duration and magnitude of rail-to-earth voltages are clearly readable.
 - 3) Resolution shall be no less than 100 ms for time and 2 V for voltage
 - b. Adjustment: Iteratively adjust the annunciation and trip setpoints until optimum settings have been determined to the satisfaction of Engineer. This process may require several weeks or more of monitoring and adjusting settings. Submit settings to Engineer after the following conditions are met:
 - 1) The substation remains on line for 14 days without a nuisance trip (tripping under normal operation without apparent reason) including times when adjacent substations are removed from service for at least 1 hour.
 - 2) The recommended settings conform to IEEE 80 for safe touch and step potential.
 - c. Final Record Chart Recording:
 - 1) For each substation, after the rail voltage monitoring and grounding devices have been set and the settings accepted by Engineer, provide a 48-hour chart recording of rail-to-earth voltages and currents measured at terminals of dc switchgear.
 - 2) Set horizontal scale so that both time duration and magnitude of rail-to-earth voltages are clearly readable.

- 3) Make recording on a weekday, during actual or simulated revenue service and make a part of the as-built record documentation.
- 4) Submit final documents for review and approval.

F. Train Start Tests:

1. Purpose: Verify that the traction electrification system will allow simultaneous trains to start in a power section under full load and adjust protection relay settings.
2. Provide two chart recorders to monitor di/dt.
3. Document results.
4. Adjust protection relay settings as necessary.
5. Submit test results for review and approvals.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 34 23 10 OCS DESCRIPTION AND GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

- A. The Traction Electrification Distribution System referred to hereafter as the Overhead Contact System (OCS) consists of all equipment needed to provide that part of the electrical circuit between the termination of the Traction Power Substation positive feeders at pole top or shop disconnect switches, and the contact wire interface with the vehicle pantograph, for the complete streetcar route, storage yard, and shop.
- B. For general Systems guidelines, refer to the Division 1 Specifications.
- C. Unless otherwise noted, the term "Owner" shall refer to the City of El Paso throughout these Specifications.
- D. Unless otherwise noted, the term "Engineer" shall refer to the City Engineer or Owner's Designated Representative, as defined in General Provisions 3.1, City Engineer's Authority/Owner's Designated Representative.
- E. Unless otherwise noted, the term "Work" shall represent the entire scope of the construction of the El Paso Streetcar project.
- F. The Contractor shall be responsible for coordinating all aspects of the Work, including but not limited to procurement, staging locations, traffic control, and all other tasks required to complete the Work.
- G. The route for revenue service is single track primarily occupying space in urban streets. The selected streets allow the creation of two loops, the Entire System Loop (ESL) and the Downtown Circulator Loop (DCL). The two loops intersect, with the South end of the ESL sharing track with the North end of the DCL, resulting in what could generally be described as a "figure eight".
- H. The ESL route follows Stanton Street on the East, Baltimore Street on the North, Oregon Street on the West, and shares Franklin Street with the DCL on the South end. The total length of the ESL is approximately 3.5 miles.
- I. The DCL route shares Franklin Street on the North end, and follows Kansas Street on the East, Father Rahm on the South, and Santa Fe Street on the West side. The total length of the DCL is approximately 2 miles.
- J. Typically the selected streets have two way traffic operations, with the streetcar occupying one of the lanes, which is generally shared with vehicles travelling in the same direction. Automobile traffic travelling in the opposite direction is generally present in the opposite lanes.
- K. The storage yard and shop is located off the southwest corner of the DCL, near the intersection of Santa Fe and Father Rahm streets. It includes inbound and outbound tracks, storage tracks, and shop tracks, all of which are fully wired.
- L. Work under this contract includes the provision of OCS doorbridge assemblies at the doors of the maintenance shop. The contractor shall coordinate the design of the selected doorbridge with the design of the building, taking full account of the form, fit, and function of the doorbridge assembly and the selected door operating mechanism.
- M. Work under this Contract includes OCS design completion, materials procurement, installation, testing, and the provision of project records, operating and maintenance manuals, training, and special tools, in accordance with OCS Contract Drawings and Specifications.

- N. The OCS Contract Drawings and Specifications provide information regarding the Work and criteria for the Contractor to complete the OCS design, and install and test the Contractor's products. The Contractor shall provide all necessary engineering to ensure that the installed OCS meets the requirements of this Specification and referenced documents and drawings.
- O. The Contractor shall prepare a Contractor's OCS Design Completion Package (see Section 34 23 10 Part 2) with all information required for the OCS installation. The Contractor shall prepare designs that detail the use of the Contractor's products to achieve the required OCS installation.
- P. The equipment to be installed includes: poles, pole foundations, cantilevers, headspans, cross-spans, conductors, feeder jumpers, terminations, sectioning equipment, disconnect switches, surge arresters, contact wire bridges, and all other OCS associated components.
- Q. The provision and installation of pole foundations are specified in the Texas Department of Transportation Governing Specifications and Special Provisions.
- R. All OCS equipment is to be energized at a nominal 600V DC, and shall be double insulated.
- S. All OCS Components shall be designed such that all fastenings and adjustments are accomplished with the same dimensional standards or tools. Metric standards or American standards (not both) shall be used throughout the OCS design.
- T. The Contractor shall coordinate with the Owner, TxDOT, and all other interested agencies regarding the Work.
- U. Double Insulation
 - 1. A minimum of two levels of electrical insulation separated by a minimum dimension of four feet shall be provided between the contact wire and a line pole or other grounded structure.
 - 2. At support structures one level of insulation shall be at the contact wire supports, and the second level shall be adjacent to the structure.
 - 3. At contact wire dead ends, two strain insulators shall be provided, separated by a minimum distance of 10 feet. Each level of insulation shall be rated to be compatible with the system insulation class.

1.2 RELATED SECTIONS

- A. City of El Paso: streetcar project technical specifications (all volumes)
- B. Texas department of transportation governing specifications and special provisions, as listed in city of El Paso: streetcar project technical specifications
- C. DIVISION 01 – General Requirements
- D. SECTION 26 – Traction Power Specifications
- E. SECTION 34 23 11.01 – OCS Glossary of Standard Terms
- F. SECTION 34 23 35.99 – OCS Pole Painting
- G. SECTION 34 23 37 – OCS Tubular Steel Poles
- H. SECTION 34 23 37.11 – OCS Pole Ornamentation
- I. SECTION 34 23 40 – OCS Wire and Cable
- J. SECTION 34 23 50 – OCS Assemblies, Components, and Fittings
- K. SECTION 34 23 64 – OCS Special Tools
- L. SECTION 34 23 66 – OCS Spare Parts

- M. SECTION 34 23 70 – OCS Installation
- N. SECTION 34 23 71 – OCS Pole Foundations
- O. SECTION 34 23 72 – OCS Tubular Pole Installation
- P. SECTION 34 23 77 – OCS Surge Arrester Installation
- Q. SECTION 34 23 78 – OCS Disconnect Switch Installation
- R. SECTION 34 23 80 – OCS Testing
- S. SECTION 34 23 90 – OCS Installation Records
- T. SECTION 34 23 96 – OCS Installation and Maintenance Manuals
- U. SECTION 34 23 97 – OCS Maintenance Staff Training
- V. Specifications for Street Lighting Attachments on OCS Poles shall be in accordance with Texas Department of Transportation Governing Specifications and Special Provisions, in conjunction with Approval from the Engineer.
- W. Specifications for Traffic Signal Attachments on OCS Poles shall be in accordance with Texas Department of Transportation Governing Specifications and Special Provisions, in conjunction with Approval from the Engineer.

1.3 REFERENCED STANDARDS

- A. The pertinent provisions of the latest revisions of the codes and standards of the applicable NEMA, IEEE, ASTM, AWS, NEC, and ANSI shall apply to the Work of this Section.
- B. If other types of materials are proposed, the Contractor shall, along with the product description, include the relevant standards and information on that material in his submittal.

1.	AISC	S302	Code of Standard Practice for Steel Buildings and Bridges
2.	AISC	S326	Design, Fabrication and Erection of Structural Steel
3.	ANSI	C29.1	Test Methods for Electrical Power Insulators
4.	ANSI	C29.2	For Insulators, Wet Process Porcelain and Toughened Glass Suspended type
5.	ANSI	C29.7	Porcelain Insulators (High-Voltage Line-Post Type)
6.	ANSI	C29.8	Apparatus, Cap and Pin Type (Wet Process Porcelain)
7.	ANSI	C37.34	IEE Standard Test Code for High-Voltage Air Switches
8.	ANSI	Z55.1	Gray Finishes for Industrial Apparatus and Equipment
9.	ASTM	A27/ A27M-10	Standard Specification for Steel Castings, Carbon For General Application
10.	ASTM	A36/ A36M-12	Standard Specification for Carbon Structural Steel
11.	ASTM	A47/ A47M-99	Standard Specification for Ferritic Malleable Iron Castings
12.	ASTM	A53/ A53M-12	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, and Welded
13.	ASTM	A123/ A	123M-12 Zinc (Hot Dip Galvanized) coatings on Iron and Steel Products

14.	ASTM	A143/ A143M-07	Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Steel Products and Procedure for Detecting Embrittlement
15.	ASTM	A153/ A153M-09	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
16.	ASTM	A167-99	Standard Specification for Stainless and Heat-Resisting Chromium Nickel Steel Plate and Strip
17.	ASTM	A283/ A283M-12a	Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
18.	ASTM	A307-12	Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength
19.	ASTM	A368-95a	Standard Specification for Stainless Wire Strand
20.	ASTM	A370-12a	Standard Test Methods and Definitions for Mechanical Testing of Steel Products
21.	ASTM	A384/ A384M-07	Standard for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies
22.	ASTM	A475-03	Standard Specification for Zinc-Coated Steel Wire Strand
23.	ASTM	A484/ A484M-13	Standard Specification for General Requirements for Stainless Steel Bars, Billets, and Forgings
24.	ASTM	A492-95	Standard Specification for Stainless Steel Wire Rope
25.	ASTM	A493-09	Standard Specification for Stainless Steel Wire and Wire Rods for Cold Heading and Cold Forging-Bar and Wire
26.	ASTM	A518/ A518M-99	Standard Specification for Corrosion-Resistant High-Silicon Cast Iron
27.	ASTM	A530/ A530M-12	Standard Specification for General Requirements for Specialized Carbon and Alloy Steel Pipe
28.	ASTM	A536/ A536-84	Standard Specification for Ductile Iron Castings
29.	ASTM	A555/ A555M-05	Standard Specification for General Requirements for Stainless Steel Wire and Wire Rods
30.	ASTM	A563-07	Standard Specification for Carbon and Alloy Steel Nuts
31.	ASTM	A572/ A572M-12a	Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
32.	ASTM	A588/ A588M-10	Standard Specification for High-Strength, Low Alloy Structural Steel, up to 50 KSI [345 MPa] Minimum Yield Point, With Atmospheric Corrosion Resistance
33.	ASTM	A595/ A595M-11	Standard Specification for Steel Tubes or High Strength Low Alloy, Low-Carbon, Tapered for Structural Use
34.	ASTM	A687-93	Standard Specification for High-Strength Nonheaded Steel Bolts and Studs
35.	ASTM	A668/ A668M-04	Standard Specification for Steel Forgings, Carbon, and Allow for General Industrial Use

36.	ASTM	A711/ A711M-07	Standard Specification for Steel Forging Stock
37.	ASTM	A747/ A747M-12	Standard Specification for Steel Castings, Stainless, Precipitation Hardening
38.	ASTM	B6-13	Standard Specification for Zinc
39.	ASTM	B26/ B26M-12	Standard Specification for Aluminum-Alloy Sand Castings
40.	ASTM	B148-19	Standard Specification for Aluminum-Bronze Sand Castings
41.	ASTM	B179-11	Standard Specification for Aluminum Alloys in Ingot and Molten Form for Castings From All Castings and Processes
42.	ASTM	B187/ B187M-11	Standard Specification for Copper, Bus Bar, Rod and Shapes and General Purpose Rod, Bar and Shapes
43.	ASTM	B248-12	Standard Specification for General Requirements for Wrought Copper and Copper-Alloy Plate, Sheet, Strips and Rolled Bar
44.	ASTM	B249/ B249M-12	Standard Specification for General Requirements for Wrought Copper and Copper-Alloy Rod, Bar and Shapes and Forgings
45.	ASTM	A580-79	Standard Specification for Stainless Steel Wire
46.	ASTM	B584-79	Standard Specification for Copper Alloy Sand Castings for General Applications
47.	ASTM	C150/ C150M-12	Standard Specification for Portland Cement
48.	ASTM	C151/ C151M-09	Standard Test Method for Autoclave Expansion of Hydraulic Cement
49.	ASTM	D116-86	Standard Test Method for Vitrified Ceramic Materials for Electrical Applications
50.	ASTM	E709-08	Standard Guide for Magnetic Particle Testing
51.	ASTM	F436-11	Standard Specification for Hardened Steel Washers
52.	ASTM	F593-02	Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs
53.	ASTM	F1554-07ae1	Anchor Bolts, Steel, 36, 55, and 105 KSI Yield Strength
54.	AWS	D1.1	Structural Welding Code, Steel
55.	NEMA	HV 2	Application Guide for Ceramic Suspension Insulators
56.	NFPA	(NEC)	Current Edition

1.4 SUBMITTALS

- A. Submittals shall be in accordance with the requirements of SECTION 01 33 00, except as modified herein.
- B. Submit a Contractor's OCS Detailed Design Completion Package as listed below and defined in SECTION 34 23 10 Part 2.
- C. General Design Information Submittals containing:
 - 1. Shop drawings
 - 2. Framing attachment height and dimension methodology and sample calculations
 - 3. Pole rake methodology and sample calculations
 - 4. OCS wire schedules
 - 5. Bills of materials

1.5 QUALITY ASSURANCE/QUALITY CONTROL

- A. Quality Control/Quality Assurance shall be in accordance with SECTION 01 43 00 except where modified within this Specification Section.

1.6 OVERHEAD CONTACT SYSTEM STYLES

- A. Single Contact Wire Fixed Terminated Style
 - 1. The wiring shall be supported and registered by means of cantilevers, or various styles of head span assemblies. At sharp curves and corners, wire pulloff or steady span assemblies may be used for registration. The contact wire shall be staggered.
 - 2. Wire terminations shall be fixed at both ends, each with capability for maintenance adjustment.

1.7 OCS POLES

- A. Tubular Poles
 - 1. There will be 5 general configurations of OCS poles on the project; sole use OCS poles, OCS poles with street lighting, OCS feeder poles, Ornamental OCS poles, and OCS poles with traffic signal accessories. In some cases there will be combinations of these configurations. OCS pole finish may vary on the project, possibly utilizing both galvanized and painted finishes. The Contractor shall verify OCS pole types and finishes with the Engineer prior to procurement. See Sections 34 23 37 OCS Tubular Steel Poles, 34 23 37.11 OCS Pole Ornamentation, 34 23 35.99 OCS Pole Painting, and the Texas Department of Transportation Governing Specifications and Special Provisions for related Specifications. OCS poles shall be procured based on these Specifications and Contract Drawings, in conjunction with Approval from the Engineer.

1.8 OCS SPAN WIRE ATTACHMENTS TO BUILDINGS

- A. OCS anchors will be required at the maintenance facility to reduce the tension in the shop contact wire, as well as to terminate the contact wire inside the building. The anchor will consist of a structural eye-bolt and other components that are deemed necessary to ensure the stability and strength of the attachment. The installation of this connection shall be subject to Inspection and Approval by the Engineer. After the attachment is approved by the Engineer, the Contractor shall be permitted to install and terminate the contact wire. Refer to the Contract Drawings (OCS Drawings and Maintenance Facility Structural Drawings) for building attachment locations, anchor bolt details, and contact wire tension information.

1.9 OCS CONTRACT DRAWINGS

- A. OCS Basic Design Contract Drawings are standard drawings showing typical OCS design features for use at site-specific locations as detailed in OCS Wiring Layouts and Schedules.
1. General Drawings: General Drawings provide standard OCS abbreviations, drawing symbology, general electrical clearance data, and sample OCS plan and schedule drawings.
 2. Technical Sheets: The Technical Sheets provide information regarding design data, parameters, conductor characteristics, conductor tensions, temperature conditions, maximum wiring spans on tangent and curved track, wind blow off data, maximum mid span offset, pantograph security, and pantograph clearance.
 3. General Arrangement Drawings: General Arrangement Drawings show the layout and dimensions for poles and wiring at overlaps, crossovers, and terminations.
 4. Typical Structure Drawings: Typical Structure Drawings provide typical arrangement views for various common functions of OCS structures. These drawings provide required dimensions, and identify assembly drawings showing typical equipment suitable for the structure's function.
 5. Assembly Drawings: Assembly Drawings are pre-shop drawings which show the arrangement of several generic components assembled as cantilevers, headspans, cross-spans, pull-offs, and other OCS equipment.
 6. OCS Layout Drawings:
 - a. The OCS Layout Drawings show structures and OCS wiring. Tables for each track indicate structure number, contact wire height, conductor termination heights, contact wire stagger and direction, and pole types. Additional information includes span lengths, location of section insulators, disconnect switches, jumpers and feeders, backbone/pull off arrangements, and other relevant information.
 - b. Electronic copies of the OCS Layout Drawings in the Contract Drawings will be made available to the Contractor within 30 days of Notice To Proceed.

1.10 AMBIENT AND CONDUCTOR TEMPERATURES

- A. The normal conductor temperature for computing erection conditions is 60 degrees Fahrenheit. The maximum conductor temperature is 120 degrees Fahrenheit. The minimum conductor temperature is 20 degrees Fahrenheit.

1.11 ICE LOADING

- A. For structural design calculations, a radial thickness of 1/4 inch ice on the contact wire and messenger wire shall be used. A radial thickness of 1/4 inch shall be used on all solid-type structures and structural members (pole brackets, cantilevers, etc.).

1.12 WIND LOADING

- A. For structural design, a maximum wind speed of 90 mph or maximum wind speed given by local codes shall be applied to poles and rigidly attached brackets.
- B. A maximum wind speed of 40 mph shall be used when there is radial ice.
- C. Maximum windspeed for streetcar operations is 55 mph, applied to conductors with no ice loading.

1.13 LEVELS AND PLACEMENT OF INSULATION

- A. A minimum of two levels of electrical insulation shall be provided. Each level of insulation shall be rated to be compatible with the system insulation class.
- B. The first level of insulation shall be installed at the contact wire support and registration equipment.
 - 1. Where assemblies connect between the contact wire and a pole or other grounded structure that is 11 feet 3 inches or less horizontally from track centerline, the second level shall be adjacent to the structure with its live end components 15 inches clear of the pole or structure.
 - 2. Where assemblies connect between the contact wire and a pole or other grounded structure that is greater than 11 feet 3 inches from track centerline, the second level shall be installed 10 feet from track centerline.
 - 3. Where two adjacent contact wires are connected to common assemblies, and are capable of being separately de-energized, a second level of insulation shall be installed midway between them. If the distance between track centerlines exceeds 20 feet, two second level insulators shall be installed, each 10 feet from a track centerline.
- C. At contact wire dead ends, two strain insulators shall be provided, separated by a minimum distance of 10 feet. The first level of insulation shall be installed so as to be 4 feet minimum and 5 feet maximum horizontally from superelevated track centerline.

1.14 CONTACT WIRE HEIGHTS

- A. The normal contact wire height at supports shall be 19 feet 6 inches.
- B. Minimum contact wire heights in streets or road crossings shall be 18 feet 0 inches after allowance for conductor sags due to temperature variations, ice loading, and conductor installation tolerances. The heights shall take into account the tolerances for track maintenance and construction.
- C. Clearances between the OCS and various overhead utilities shall be in accordance with the National Electrical Safety Code, and these Contract Drawings and Specifications.

1.15 CONTACT WIRE GRADIENTS

- A. The maximum rate at which the contact wire shall change its elevation relative to the track elevation shall be as follows:

Constant Gradient	2%
Gradient Change	1%
- B. The maximum line speed limit shall be 35 mph for OCS purposes.

1.16 PANTOGRAPH SECURITY

- A. The minimum allowable pantograph security shall be 6 inches.

1.17 CONTACT WIRE RADIAL LOADS

- A. The contact wire deviation at any single, contact wire swivel clamp shall not exceed 7 degrees.
- B. Where the contact wire registration loads exceed 500 lb, two steady arms shall be used.

- C. Steady arm shape and heel settings shall be designed and installed in accordance with Contract Drawings.
- D. The heel point of the steady arm shall be outside of the limits of the pantograph envelope under both static and uplifted conditions.

1.18 FACTORS OF SAFETY

- A. The OCS shall be designed with the following minimum factors of safety under the temperature, wind, and ice loadings specified:

Equipment	Minimum Safety Factor
Conductors:	
Operating	2.0
Non-Operating	1.6
Hardware, assemblies, fittings, components, and non-electrical wires:	
Operating against breakage	2.5
Operating against slippage	2.5
Non-Operating against breakage	2.0
Non-Operating against slippage	2.0
Structures designed per AISC (LRFD/ASD)	

- B. The permitted wear of the contact wire shall be 30% of its original cross-sectional area. The safety factors stated above shall apply to the contact wire when worn.

1.19 PANTOGRAPH CLEARANCE ENVELOPE

- A. The installed OCS, including the steady arm in the uplifted position, shall not intrude into the pantograph clearance envelope for the applicable contact wire height. For the pantograph envelope and related clearance requirements under various conditions, see OCS Technical Sheets.
- B. For test purposes, the contact wire shall be lifted with the test pantograph by 3 inches from the free hanging condition, to verify clearance with uplift. In addition, 0.5 inches of pantograph carbon wear will be allowed from a new carbon outline on the test pantograph.

1.20 ELECTRICAL CLEARANCES

- A. The OCS shall be designed for a minimum static electrical clearance of 4 inches. Refer to SECTION 34 23 11.01 for definitions of static and passing conditions.
- B. All erected poles, brackets, switch operating handles, and other Contractor-installed equipment shall comply with the electrical clearances given in the OCS Drawings.
- C. Minimum electrical clearances shall apply after all applicable design allowances and construction tolerances have been accounted for.

1.21 MECHANICAL CLEARANCES

- A. All erected poles, brackets, switch operating handles and other Contractor-installed equipment shall comply with the Streetcar clearance requirements of the current issue of the Design Criteria document.

1.22 TOLERANCES

- A. Unless otherwise specified in the Texas Department of Transportation Governing Specifications and Special Provisions, pole foundations constructed shall have the following dimensional erection tolerances applied relative to the Contract Drawings:
 - 1. Foundation offset from track centerline: 2 inches
 - 2. Stationing along track Centerline adjacent to special trackwork: 2 feet
 - 3. Stationing along track centerline at street intersections: 1 foot
 - 4. Stationing along track centerline on open track: 5 feet
 - 5. Span length change between adjacent pole foundations 5 feet

1.23 RETURN CIRCUIT

- A. See Traction Power Specifications for Return Circuit information.

PART 2 - PRODUCTS

2.1 CONTRACTORS OCS DESIGN COMPLETION PACKAGE

- A. Electronic copies of the OCS Drawings in the Contract Drawings shall be provided to the Contractor.
- B. The Contractor's OCS Design Completion Package shall consist of the following:
 - 1. Shop Drawings.
 - a. Shop drawings for each OCS Assembly shall be produced and submitted for approval. Each Assembly drawing shall show the arrangement of OCS fittings and the pantograph clearance envelope for the designed contact wire height where applicable. Drawings shall also show minimum track offset, superelevation, and any other pertinent information where the assemblies will be installed.
 - b. Shop drawings relating to Cantilever Assemblies shall include the following:
 - 1) All cantilevers shall have double insulation. One level shall be at the conductors, and one level at the connection to the pole brackets.
 - 2) The reach of any cantilever shall not be more than three times the dimension between its support brackets on the pole, unless verified through calculation or modeling to verify structural adequacy.
 - 3) Drop-tube of cantilevers shall be checked during cantilever design to ensure minimum 1 inch running clearance to the pantograph clearance envelope.
 - c. Shop drawings relating to headspan, cross-span, or pull-off assemblies shall include the following:
 - 1) All headspans, cross-spans, and pull-off assemblies shall be double insulated.
 - 2) Cross-span insulation shall be provided in headspan wires, cross-span wires, span guys, and pull offs in accordance with the requirements as shown in the Contract Drawings and Specifications.
 - 3) Headspans shall be designed with minimum sag approximately equal to $\text{Span}/8$.
 - 4) The minimum headspan attachment height at a pole shall be equal to the top of the adjacent messenger wire/contact wire support assembly plus $\text{span}/8$.

- 5) Attachment heights for the (upper) headspan wires shall be a minimum of 6 inches below the tops of poles, or, where relevant, streetlight attachment points.
 - 6) Pull off assemblies shall only be used where total radial loadings on the steady arm at the opposite end of the assembly from the support exceed 200 lb at any temperature or wind condition. Where this condition cannot be met, steady span (double ended pull-off) assemblies shall be installed.
- d. Shop drawings of assemblies and products shall be produced such that they demonstrate that the required OCS functions and configurations are achieved.
 - e. Each shop drawing shall be given an Assembly Reference that shall match the equivalent Contract Assembly Drawing and shall carry the same title.
 - f. Each shop drawing shall have a bill of materials listing all components, and include their part or catalog number, descriptive text, quantity required, and unit of measure.
 - g. Each shop drawing shall show details of all components including electrical characteristics, materials, dimensions, load ratings, and weights.
 - h. Calculation and documentation of cantilever, headspan, cross-span, pull off, and backbone assemblies shall provide loads, geometry, maximum and minimum dimensional limits, and application rules. This documentation shall be produced for the maximum loadings for each type of assembly.
 - i. Methodology and calculations used to determine pole rake and orientation shall be submitted.
 - j. OCS wire schedules shall be produced for all conductors to be installed
 - k. Projectwide Bill of Materials identifying all OCS components and component quantities used in the OCS installation shall be submitted. The Contractor shall furnish this information in tables as described below:
 - 1) OCS components listed in alphabetical order.
 - 2) OCS components listed in order of catalog number.
 - l. Contractor's OCS Layout Plan design update drawings shall show the final installed showing:
 - 1) Assembly references for cantilevers, headspans, pull-offs and registration types attached to each structure.
 - 2) Pole rake values and orientation dimensions.
 - 3) Design changes due to Contractor's equipment selection.
 - 4) Design changes affecting material selection and/or OCS structure location or offset.
 - m. Wiring dimensions for all head span, cross-span, pull-off and backbone assemblies.
 - 1) Shop drawings for any single site specific assemblies or components that are not included in the Contract Drawings. Site measurement records, and design calculations for any such sites shall also be submitted.

2.2 DRAFTING STANDARDS

- A. The Contractor's Drawings submitted in electronic form should be drafted in accordance with Drafting Standards approved by the Engineer.

PART 3 - EXECUTION

3.1 DESCRIPTION OF WORK

The Contractor shall design, furnish, and install the OCS for the Project as described and referenced in the following.

- A. Perform Design Completion, as described in these Specifications, including but not limited to the following.
 - 1. Performing and submitting calculations to verify assembly and component adequacy.
 - 2. Producing and submitting shop drawings of all assemblies and components.
 - 3. Producing assembly and component test reports and certificates of compliance as described in these Specifications.
 - 4. Producing and submitting installation plans, test plans, and all other pertinent OCS design and installation documentation as described in these Specifications.
- B. Supply and install OCS conductors, OCS poles, OCS foundations, cantilevers, cross-spans, headspans, pull-offs, section insulators, any special pole or wiring anchors, and all other OCS components in accordance with the Contract Drawings and these Specifications.
- C. Perform and submit the required OCS system testing and documentation as required in these Specifications.
- D. Perform as-built measurements and drawing updates to be submitted as required in these Specifications.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 34 23 11.01

OCS GLOSSARY OF STANDARD TERMS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section contains a glossary of Overhead Contact System (OCS) terms that define words and terms used in the Contract OCS Drawings and Specifications. The Systems Contractor shall ensure that supplied shop drawings, Test Certificates, OCS records and other OCS documentation required by the OCS Specifications use the preferred terms given in this Specification.

1.2 RELATED DOCUMENTS

- A. For general electrical terms, see "IEEE Standard Dictionary of Electrical and Electronic Terms", IEEE Standard 100 - Latest Edition
- B. For insulated cables, the definitions of terms shall be in strict accordance with applicable publications of ICEA for the cable provided.

1.3 GLOSSARY OF TERMS FOR OVERHEAD CONTACT SYSTEMS

- A. The purpose of this glossary is to provide uniform terminology and definitions for technical terms used in design of the Overhead Contact System. These terms will form the basis for assembly descriptions used in material allocation and control. The glossary does not include standard transit and electrical engineering terms, but is intended to define terms for which industry standard definitions have not been universally adopted, especially those related to Overhead Contact Systems.

Terms marked with an asterisk (*) are not preferred. Use preferred terms.	
Anchor	
anchor bolt	A bolt inserted into a concrete foundation to form an attachment for a pole or support bracket.
Anchor base pole*	See "bolted-base pole".
Arrangement Drawing (OCS)	A group of structures in a specific configuration providing the wiring of a typical short section of OCS; e.g., overlap, crossover.
Assembly Drawing (OCS)	A configuration of components used repetitively in the OCS, and identified in combination as a group for ease of reference.
Assembly Reference	An alpha numeric code assigned to a discrete group of components of discrete design and discrete number that comprise a discrete assembly.
AWG	American Wire Gauge
Backbone	A span guy or wire between structural supports used primarily to register contact wires around a curve by means of a set of registrations attached along the backbone.
Backguy*	See "Guy".
BIL	Basic Impulse Level
Blow-off	Lateral displacement of the contact wire due to wind.
Body span wire	The center span wire of a three-wire Headspan.
Bolted – base pole	A pole for use on a foundation with anchor bolts (as opposed to plain pole which is embedded in earth or concrete).

Terms marked with an asterisk (*) are not preferred. Use preferred terms.	
Bond –	An electrical connection between metal hardware to eliminate voltage difference.
impedance bond	An inductive device bridging an insulated rail joint used for allowing passage of DC traction return current while preventing passage of high-frequency current used for signaling.
rail bond	Electrical connection between adjacent lengths of rail.
structure bond	An electrical connection between structure and rail or impedance bond.
Bracket or gain*	A connection to a pole by means of which the cantilever or bracket arm assembly is attached to the pole.
Bracket arm or Mast arm*	The frame assembly supporting a direct suspension single contact wire system from a pole (A bracket arm which is hinged to pole has the preferred term “cantilever”).
Bridge*	See “Overpass” or “Underpass”.
Break*	See “Section break”.
Bridle	A span guy or wire between structural supports used primarily to provide vertical support to a cross-span wire attached approximately midway along the bridle.
Bull ring	A steel ring usually 2-4 inches in diameter into which two or more span guys are connected.
Bypass switch	A disconnect switch at a non-feeder sectionalization point in the OCS.
Cable outlet	A short pipe installed through the wall of a tubular pole, through which a feeder cable exits the pole.
Carbon collector*	See “contact strip”.
Cantilever	The support frame and registration assembly supporting the catenary from a pole, and attached to the pole via hinge fittings.
Catenary –	The combination of conductors, hangers and in-span hardware of the overhead contact system used in LRT operation, not including supports and cantilevers.
dictionary meaning	The curve assumed by a perfectly flexible weighted cord of uniform density and cross-section hanging freely between two fixed points.
simple catenary	Comprising a contact wire supported from a messenger wire by hangers.
compound catenary	Comprising a contact wire, an auxiliary wire and a messenger wire, with associated hangers.
stitched catenary	A catenary system to which a stitch wire has been added at the supports to improve catenary dynamics.
tramway equipment* or single contact wire	Comprising a contact wire only.
Chording of curves	On curved route the propensity of the contact wire to “cut the curve” between registrations.
Circular mil	One thousandth part the area of a circle one inch in diameter.
Clamp –	

Terms marked with an asterisk (*) are not preferred. Use preferred terms.	
contact swivel clamp	The fitting on the end of the steady arm or registration pipe which attaches to the contact wire.
parallel groove clamp	A piece of hardware used to clamp two parallel wires together.
pipe clamp	A piece of hardware used to attach various types of components to a pipe.
strain clamp	A piece of hardware used for deadending a wire or conductor under high mechanical tension.
suspension clamp	A piece of hardware used to support a tensioned conductor or cable in a hanging arrangement, the greater part of the applied load being due to gravity.
Clipping in	The process of sagging an overhead wire to correct tension and clamping it at the support and fixing the hangers.
Commutation	The act of picking up electrical power from an overhead contact wire by pantograph.
Component	An item of hardware as commonly supplied complete by a manufacturer.
Contact bridge	A rigid bar, fixed closely above and attached to the in-running contact wire forming a slot for a second contact wire to pass through, thereby preventing differential uplift of crossing contact wires. Also called a "wire cross".
Contact Strip	The replaceable wearing part of the pantograph collector head assembly which interfaces with the overhead contact wire for collecting current.
Contact wire or Trolley Wire*	The wire of an OCS with which the pantograph of a Streetcar makes contact for current collection. Normally made of copper or bronze, the wire is a single conductor with a groove to which hangers and clamps may be fitted.
Contact wire height –	The height of the underside of the contact wire above rail level when not uplifted by the pantograph.
minimum contact wire height	The minimum allowable contact wire height, usually at midspan or under bridges, which takes due account of vehicle clearance envelope, vehicle bounce and track tolerances, catenary temperature effects and electrical clearances. May also take future track raising into account if so required.
maximum contact wire height	The maximum allowable contact wire height within the operating range of the vehicle current collector.
Copperweld conductor	A wire with a steel center and a layer of copper fused around it or a number of such wires stranded together.
CR	Conduit Riser
Creep	The on-going permanent stretch of copper wires under mechanical tension for long periods of time.
Crossarm*	See "Cantilever", "bracket arm".
Cross level	The plane through the tops of the rails of a track in the transverse direction.
Cross level tolerance	See "Track tolerances".
Cross-span	An installation of wires that crosses the track or roadway at approximately contact wire level; more specifically a single or double wire fastened to poles on either side of the route and supporting one or more contact wire(s).

Terms marked with an asterisk (*) are not preferred. Use preferred terms.	
Current collector	The rubbing strip at the top of a pantograph which rides along under the contact wire.
Curve Supports –	
inside curve	An arrangement for an OCS where the poles are on the inside of the curve, relative to the track.
outside curve	Poles are on the outside of the curve, relative to the track.
CW	Contact Wire
DGA	Down Guy Assembly
Direct Suspension Overhead Trolley Contact System	Wherein the trolley contact wire is attached by suitable devices directly to the main supporting system.
Double insulation	Insulation function provided by two physically separated insulators, installed at a nominal minimum and maximum spacing.
Droop	Fall of a conductor from its position at normal temperature, due to temperature change and/or ice coating.
Dropper*	See “Hanger”.
Drop bracket	An assembly fixed to the underside of a registration pipe that carries the steady arm.
DSW	Disconnect Switch
Dynamics or catenary dynamics	The interactive relationship between pantographs and contact wires at operating speeds; commutation performance.
Elastic system	A term applied to an overhead system where the contact wires are free to uplift under the pressure of the current collectors at the supports. Usually pendulums comprising one hanger or two articulating parallel hangers.
Electrical clearance –	
passing	The dimensional mechanical clearance between live part of either the vehicle (such as uplifted pantograph) or catenary and grounded parts of the fixed structures, due to the dynamics of the passage of a moving or stationary vehicle. See AREMA Standards Chapter 33.
static	The dimensional mechanical clearance between live parts of the OCS and grounded parts of fixed structures, in the absence of pantographs.
Embedded poles	Poles without base plates, directly inserted into socket-type or open foundations and fixed by grout or compacted backfill such as sand.
Encumbrance*	See “pole encumbrance” and “system height”
Envelope –	
vehicle static envelope	The maximum envelope of a static vehicle
vehicle dynamic envelope	The maximum envelope of a moving vehicle when it is free to lurch and sway.
combined vehicle envelope	The vehicle dynamic envelope plus the effects of maximum track alignment and cross-level tolerances.

Terms marked with an asterisk (*) are not preferred. Use preferred terms.	
structure clearance envelope	The combined vehicle envelope plus a safety clearance allowance typically 6 inches all round.
pantograph clearance envelope	The combined clearance envelope of the pantograph plus a lateral allowance for safety and vertical allowance above static contact wire level. Only steady arms and registration arms are permitted within this envelope.
Equation*	See Station Equation.
Equivalent span or ruling span*	A mathematically weighted average span of a given tension length of conductors used in sag-tension calculations.
Exclusive right-of-way	Right-of-way only accessible to Owner's own vehicles and maintenance personnel.
Eye bolt	A bolt embedded in the face of a building or other structure with an "eye" or "ring" at the exposed end, for attachment of span guys.
Face of pole	The absolute nearest part of a pole from the track but excluding the base plate unless this is located significantly above the level of the rails and intrudes into the clearance envelope.
Facing turnout	A track turnout oriented to be directly entered in the normal direction of travel (see also Trailing turnout).
Feeders	Conductors which supply power to or augment the power-carrying capacity of the conductors in an overhead contact system.
Feeder spout* or feeder outlet*	See "Cable Outlet".
Finial*	See "Pole Cap".
Fittings	Small components used in assembly of cantilever pipes and catenaries
Fixed-terminated (FT) equipment	OCS with dead-ended conductors at both ends.
FTA	Fixed Termination Anchor
Frog (Track)	A rail component used at the intersection of two running rails to provide support for wheels and passengers for their flanges, thus permitting wheels on either rail to cross the other.
Gain*	See "bracket".
Galv.	Galvanized
Gauge –	
load gauge	The envelope around the track within which all loaded track vehicles are specified to remain while static or in motion.
track gauge	The distance between the inside running edges of the track.
electrical umbrella*	The electrical clearance envelope for the pantograph in the swayed position over its operating height range. See also "pantograph clearance envelope".
pole gauge	The thickness of steel in a tubular pole.
Grade crossing	A crossing of a highway, railroad track, other fixed guideway, or pedestrian walk or combination of these at the same level.
Grade separation	A vertically separated crossing of a highway or walkway from a rail track by the provision of a bridge or underpass.

Terms marked with an asterisk (*) are not preferred. Use preferred terms.	
Gradient (contact wire)	The average slope of the contact wire between two adjacent catenary supports measured relative to the track.
Ground wire	The conductor installed for the purpose of providing electrical continuity between the supporting structure of the overhead contact system and the common return or grounding system.
GRS	Galvanized Rigid Steel
Guy –	A steadying or positioning wire.
down guy or back guy*	A wire attached high on a pole and coming down at an angle to an anchor in the ground.
head guy or span guy	A wire between two points but not anchored to ground.
sidewalk down guy	A down guy which is diverted to a vertical position for anchorage to the ground, by use of a horizontal strut braced against the pole at a high level. Used where the normal down guy anchorage would obstruct a sidewalk or other pathway.
guard	A (yellow) plastic strip which fits around the lower end of a down guy for increased visibility. Required to extend 8 feet minimum above ground.
HD	Hard Drawn
Hand hole	An access hole in a pole for cable installation or inspection.
Hanger	A wire assembly by means of which the contact wire is suspended from the messenger wire at regular intervals (typically every 15-30 feet).
Headspan	An installation of two or more wires that crosses the tracks and supports a simple catenaries, or several single contact wires in multi-track area.
Heel of steady arm	The pivoted end of a steady arm opposite to the end with the contact wire clamp.
Heel Setting	The dimensioned height of the pin at the heel of a steady arm or registration pipe above the plane of the contact wire.
Horns	The curved or angled downwards ends of the pantograph head which ensure movement of out-of-running wires onto the contact strip.
ID	Identification or Internal Diameter
I&M	Installation and Maintenance
Impedance bond	See “bond”.
In-running catenary	The catenary in multiple catenary sections (such as overlaps) providing the passage for the pantograph.
Insulator –	Any body or substance provided and designed for the purpose of surrounding, supporting or interrupting an electrical conductor so as to restrict the flow of electricity to a desired path.
bell or disc	A bell shaped insulator of glass or porcelain used singly or in strings.
Johnny ball*	A type of strain insulator used primarily for guy or span wire insulation.
no-bo	The brand name for a type of section insulator without skirts.
section	See “section insulator”.
standoff	A solid core insulator with bending strength.

Terms marked with an asterisk (*) are not preferred. Use preferred terms.	
strain	An insulator or a string of disc insulators used in line with a tensioned conductor.
strut	A standoff insulator used in compression members of cantilevers.
suspension	An insulator or string of disc insulators which are suspended in vertical position.
synthetic	An insulator made from fiberglass, plastic or epoxy resin.
Insert	A mechanical screw socket-type fixing for direct embedment into concrete usually placed before concreting.
Insulated overlap	A sectionalization point in an OCS formed by cutting insulation into the out-of-running sections of the two overlapping catenaries.
Jumper –	Generally an internal electrical connection in the overhead contact system; a short conductor assembly installed to provide electrical continuity.
continuity or full current	A jumper capable of carrying full line current from one catenary to another longitudinally at tensioning overlaps and track turnouts.
equalizing	A light internal jumper in the OCS, connecting the messenger to the contact wire for electrical continuity. Generally once in each span.
kcmil	One thousand circular mils
LF	Linear foot/feet
LS	Lump sum
Lightning Arrester*	See “Surge Arrester”.
Line guard	A bunch of short (12 inch) wires with preformed twist that self lock around a conductor and used to prevent abrasion of the conductor.
Live –	
live load (structural)	A load or force that is temporary in nature such as wind, ice, and the dynamic uplift force of a passing pantograph.
live wire (electrical)	A conductor carrying a voltage for power supply.
Load gauge	See “gauge”.
Lug –	
crimped	An attachment to the end of a wire for an electrical connection made using a compression or crimping tool.
terminal	A crimped, bolted or a soldered piece with a hole, used to terminate a wire for electrical connection.
Mast*	See “pole”.
Mast arm*	See “bracket arm” or “cantilever”.
Maximum sag	The sag of conductors either at maximum conductor temperature or under a given radial ice loading, whichever is greater.
Maximum operating wind speed	The maximum wind speed in which vehicles will continue to be operated at their normal speed. The wind speed selected for pantograph security calculations. Typically 55 mph for LRT Systems.

Terms marked with an asterisk (*) are not preferred. Use preferred terms.	
Messenger	The uppermost conductor in a catenary system. The conductor which hangs in the approximate shape of a catenary from which the contact wire is suspended by hangers.
MH	Manhole
Middle ordinate*	See “stringline”.
Midpoint anchor	The point approximately midway between two balance weights of a tension length of auto-tensioned equipment where the catenary is anchored against along-track movement.
Midpoint guy or tie wire*	The span guy that provides the midpoint restraint in auto-tensioned equipment.
Midpoint guy pole	The pole, normally with a down guy, that takes the load from the midspan guy.
Midspan offset (MSO)	The deviation of the static contact wire from the superelevated centerline of track at midspan.
MOW	Maintenance of Way Division of Owner
MPA	Midpoint Anchor assembly
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NESC	National Electrical Safety Code
No-load tension or unloaded tension*	The tension to be applied to a messenger alone so that, once the contact wire is suspended from the messenger, the messenger assumes its desired final sag and tension.
Non-riding*	See “out-of-running”.
OCS	Overhead Contact System
O&M	operations and maintenance
Offset –	
contact wire offset	The deviation of the static contact wire from the normal center – line of the track.
Pole offset	The dimension of the centerline of the pole from the centerline of the track.
Out-of-running (OOR) catenary	The portion of catenary in multiple catenary spans that does not provide for passage for the pantograph because it is higher than, or offset from, the in-running catenary.
Overhead Contact System (OCS)	That part of the traction power system comprising the catenary (or single contact wire), aerial feeders, catenary supports, foundations, balance weights and other equipment and assemblies, that delivers electric power from the traction substation to rail vehicles.
Overlap	That portion of the overhead contact system where the contact and messenger wires of two adjoining tension lengths overlap before terminating.
Overlap poles	The structures which position the two contact wires in parallel within an overlap section.

Terms marked with an asterisk (*) are not preferred. Use preferred terms.	
Overlap span	That portion of the Overhead Contact System between two structures, where the contact and messenger wires of two adjoining tension lengths overlap, thus allowing pantographs to transition from one tension length to the next under power.
Overpass or overbridge*	Where a street. Pedestrian walkway or railway crosses above the LRT tracks.
Pan*	An alternative name for the Collector Head of a pantograph.
Pantograph	A current collection device fitted on top of an electrically powered rail vehicle, hinged to vary in height as it rubs along the underside of the contact wire.
Pantograph clearance envelope	See "Envelope, pantograph clearance envelope"
Pantograph head	The uppermost part of the pantograph which is fitted with the current collector.
Pantograph Security	The analysis of the lateral relationship between pantograph and contact wire that makes due allowance for vehicle and pantograph sway, track tolerances, superelevation, erection tolerances, windage on wires and poles.
Pantograph sway	Lateral displacement of the pantograph induced by vehicle roll and lateral shock loads. Typical maximum value is 1 1/2 inch each way
Pantograph up-lift	The distance the contact wire is lifted as a pantograph passes.
Pantograph pressure or Pantograph up-thrust*	The nominal upward force exerted by the pantograph on the contact wire. Typically 18 to 22 pounds.
Parallel running (length)	The design length where the two parallel contact wires in an overlap are suspended at the same height.
PCD	Pitch Circle Diameter
Pendulum support	A type of support using two parallel hinges typically 12-24 inches long to support the contact wire keeping the contact wire vertical as it lifts freely.
Pole or mast*	An independent slender vertical structure with or without guy, used to support some part of the OCS.
Pole cap	The attachment over the top of a pole to prevent intrusion of rain water. Ornate designs may be called "Finials".
Pole encumbrance	The across-track outside dimension of a pole and its attachments at vehicle level.
Pole face	<ol style="list-style-type: none"> 1. The side of the pole to which the cantilever or bracket arm is attached. 2. The side of the pole facing the track.
Portal	A frame support structure consisting of vertical columns supporting each end of a horizontal beam.
Pre-emption device	A switch operated automatically by LRV's in city streets, which controls traffic signals to their favor.
Preformed End Fitting	A trade name for a wrap-around type of dead end or guy grip.
Presag	The static difference between the average contact wire height at the end hangers in a span and the height at midspan. Typically span/1000 in value.

Terms marked with an asterisk (*) are not preferred. Use preferred terms.	
Prestress (of conductors)	The erection tension applied to conductor at a higher tension than normal to reduce the short-term wire creep.
Profile (overhead)	The vertical alignment of the OCS conductors relative to the track.
Pulley	A pulley block used in messenger support and catenary termination systems.
Pull off/push off	The registration towards or away from centerline of track in relation to the pole.
Rail bond	See “bond”.
Radial load	The horizontal load on a structure applied by conductors due to deviation of the contact wire at registrations.
Rake	Lean of the pole from vertical.
Registration	Lateral support of conductors to maintain a fixed horizontal location relative to the track.
Rigid trolley system	An overhead contact system using an un-tensioned contact wire, relying on structural support at close spacing to supply the necessary rigidity.
Riser	A vertical cable supplying power upward from an underground feeder system to the OCS.
ROW	Right-of-way
RMS	Root-mean-square
R,S & I	Rules, Standards and Instructions
Rubbing strip*	See “Contact Strip”
Ruling span	See “equivalent span”.
Running edges	The inside faces of the rail heads of a track.
SA	Surge Arrester
Saddle	The fitting that supports a hanger on the messenger wire, sometimes fitted with an insulated lining to prevent current entering the hanger.
Sag	The difference between the average heights of the conductor at adjacent supports and its height at the lowest point in the span.
Sagging	The act of installing messengers and other conductors to the correct tension by measuring conductor sag.
Sag-tension charts	Charts referred to during wire stringing that give conductor tensions related to conductor temperature during the sagging operation.
SCW	Single Contact Wire (System)
Sectionalizing or sectioning*	The division of an electrical distribution system or network into electrical sections.
Section break	An electrical break in the overhead contact system permitting isolation of a sections of catenary electrically.
Section insulator or section isolator*	A device for dividing a contact wire (and messenger wire) into two electrical sections while maintaining mechanical continuity and a continuous path for the pantographs.
Shop door bridge	A device in doorways of maintenance shops that bridges the gap in the contact wire which is needed to allow the overhead doors to close.
Sidewalk guy	See “guy”.

Terms marked with an asterisk (*) are not preferred. Use preferred terms.	
Single wire system*	See “catenary – single contact wire”.
SL	Stringline
Sleeve –	
pipe sleeve	A short length of smaller diameter pipe fitted into a larger diameter pipe to reduce the internal diameter of the larger pipe.
sleeve foundation	A custom designed circular concrete tube placed in a drilled hole to provide a foundation for an embedded pole.
chaffing sleeve	A sleeve around a conductor to reduce damage from abrasion.
reinforcing sleeve	A steel sleeve placed around a steel pole at ground line to protect against corrosion damage.
repair sleeve	A sleeve around a conductor to repair local electrical damage.
Small Part Steelwork (SPS)	Steel brackets, frames, links and yokes, etc, which are cut from stock steel sections for attachment of catenary assemblies, but not constituting part of a principal support structure.
Single wire system	See “catenary”.
Soffit	The underside of a tunnel roof or bridge deck.
Span or Actual Span Length	The horizontal length of contact wire between two adjacent support points (not necessarily the distance or difference in stationing between the support structures).
Span guy	See “Guy, Span Guy”
Span length	The distance along track between structures determined by difference in stationing.
Span width	The distance across track or roadway (may be skewed) between the columns of a portal, headspan, or cross-span.
Spiral	The transition from tangent to curve track along which superelevation increases from zero to the selected value for the curve, and vice versa.
Spout	See “cable outlet”.
Square mil	One thousandth part of the area of a one inch sided square.
STA	Station (for survey or location purposes)
Stagger	The offset of the contact wire from the superelevated track centerline by registration at each support, that causes the contact wire to sweep side to side over the pantograph head during vehicle operation.
Stand-off insulator	See “insulator”.
Station Equation	Typically the mathematical adjustment at a point along an alignment where the normal stationing is interrupted or restarted.
Steady span	A cross span guy for contact wires, usually the lower of two horizontal span guys.
Steady arm or registration arm*	The lateral restrainer on the contact wire at a structure.
Step and touch potentials	The potential difference between points of contact – if between hand and feet it is called “touch”, if between feet, “step” potential. (See IEEE Dictionary)

Terms marked with an asterisk (*) are not preferred. Use preferred terms.	
Stringing	Installation of overhead wires under tension.
Stringline	The distance between the track arc and its chord between catenary support structures, measured at midspan.
Structure	A principal support for the OCS conductors, normally including foundation, pole(s), and cantilever(s)/bracket arm(s) or headspan/cross-span; or eyebolts and cross-span.
Subassembly	A configuration of components forming part of a larger assembly.
Superelevation effect	Displacement from the vertical track centerline due to track superelevation.
Surge Arrester or Lightning Arrester*	A device typically mounted on OCS poles and connected to the OCS, designed to protect the OCS and adjacent equipment, e.g. traction power substations and feeder cables, against lightning. Surge arresters typically provide a path to ground through variable resistance elements.
Synthetic guy strand	A synthetic rope material used in cross-span guying.
System depth* or System height	The vertical distance between messenger and contact wires, at the support structure.
Tensioning	A method of controlling sag in an OCS by tension or by weight.
Tension length or Tension section*	A length of OCS between two corresponding terminations with automatic tensioning or fixed terminations.
TES	Traction Electrification System comprising the Traction Power System (TPS) and the Overhead Contact Systems (OCS).
TOR	Top of rail (as a vertical datum)
TPFS	Traction Power Feeder System
TPS	Traction Power System, comprising the Traction Power Substations (TPSS) and the Traction Power Feeder System (TPFS) (i.e. ductbanks and traction power feeder and return cables).
TPSS	Traction Power Sub-Station
Track raising allowance	An allowance of vertical clearance specified when determining minimum contact wire heights, to cater for future lifting of tracks.
Track tolerances –	Variations from design dimensions of track.
cross level	Allowable variation between the levels of the two rails (or the designated difference in levels on superelevated track).
lateral	Allowable variation in the track alignment.
track gauge	Allowable variation from 4 feet - 8 1/2 inch.
vertical	Allowable variation in track height.
Travelers	Sheaves used in pulling wires during stringing preferably with one “cheek” that can be opened for inserting wires and pull lines.
Trailing turnout	A turnout oriented to junction two tracks converging from behind in the normal direction of travel.
Trolley wire *	See Contact wire.
Tunnel support	A catenary, feeder, or return wire support for use in tunnels and normally mounted in the tunnel soffit.

Terms marked with an asterisk (*) are not preferred. Use preferred terms.	
Turnout	The arrangement of a track switch and a frog with closure rails by which vehicles can be diverted from one track to another.
UL	Underwriters Laboratory
Underpass or Underbridge*	Where a road or river crosses beneath the LRT tracks.
Underbridge supports	OCS supports used beneath overpasses and normally attached to their soffits.
Uplift –	The difference in height of contact wire when at rest and when subjected to an upward force due to current collectors passing.:

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 34 23 35.99 OCS POLE PAINTING

PART 1 - GENERAL

1.1 SUMMARY

- A. The Work specified in this Section covers the manufacture, supply, and application of all materials and methods used for factory painting of OCS poles.
- B. At various locations on the streetcar system, hot-dipped zinc galvanized coated poles shall be painted with an exterior three-coat paint application over the galvanizing. A general description of the required finish required on pole types throughout the system is given below. The contractor shall verify these with the Engineer prior to procurement.
 - 1. All poles throughout the project shall be painted, unless otherwise directed by the Engineer.

1.2 RELATED SECTIONS

- A. The Contractor shall familiarize himself with the contents of the following Sections of these Specifications:
 - 1. SECTION 01 33 00 – Submittal Procedures
 - 2. SECTION 34 23 37 – OCS Tubular Steel Poles
 - 3. SECTION 34 23 37.11 – OCS Pole Ornamentation

1.3 SYSTEM DESCRIPTION

- A. Painted OCS poles shall be supplied from the manufacturer in a finished condition. Any paint damage requiring field touch-up painting shall conform to these Specifications.
- B. The Contractor shall be responsible for this Work in its entirety.

1.4 REFERENCES

- A. The following standard shall apply and are made a part of this Specification:
 - 1. American National Standards Institute (ANSI)

1.5 SUBMITTALS

- A. All submittals shall be made in accordance with SECTION 01 33 00 Submittal Procedures, except as modified herein.
- B. Color samples shall be submitted to the Engineer for Approval prior to application to poles.
- C. Paint data, preparation, and application procedures as specified shall be submitted to the Engineer for Approval prior to painting.

1.6 DELIVERY, STORAGE AND HANDLING

- A. All painted poles shall be handled and stored by the Contractor so as to not damage the paint or coatings.
- B. The storage of paint and its associated mixes shall be in accordance with the paint manufacturer's written instructions and shall not alter the composition of the paint such that the qualities are altered or otherwise lost.
- C. The Contractor shall insure that the storage of all flammable paints and solvents is in accordance with all Federal, State, and Local requirements.

1.7 WARRANTY

- A. The finished coating shall be guaranteed to last a minimum of 5 years, with no visible paint peeling, blistering, cracking, fading, or surface corrosion evident or occurring within that period.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. The term Paint, as used herein, includes coatings, emulsions, enamels, varnishes, paints and other protective sealers, whether used as a prime, intermediate or finish coat.
- B. The types of paint approved for use on OCS poles are as follows:
 - 1. Primer paint to be a rust-inhibitive, high build epoxy coating, quick dry-recoatable, applied over a finished hot-dipped galvanized base component system having 1.5 mil thick (minimum) paint dry-film coat; equivalent to Sherwin Williams Industrial Recoatable Epoxy Prime (B67 Series).
 - 2. Intermediate and Top Coating - To be acrylic polyurethane resin coating resistant to weather, abrasion and salt solutions, fast-dry product having a wide selection of available colors, semi-gloss, two-coat system, each coating to be 1.5 mil dry-film thickness, equivalent to Sherwin Williams Industrial Hi-Solids Polyurethane Resin (B65 Series).
- C. All paint products and coatings shall be selected, purchased, and used on the basis of a normal exterior exposure in an urban area with low humidity, intense sunlight, and temperatures ranging from -20 degrees to 120 degrees Fahrenheit. All paint products and coatings must be designed for this environment, having excellent resistance to corrosion, weathering, and demonstrating superior color retention.
- D. Paints intended for use in the field shall be stored in sealed containers that legibly show the designated name, formula, batch number, color, quantity, date of manufacture, manufacturer's number and directions including storage, special precautions, and warnings.
- E. The Contractor shall provide the following information for all paint used:
 - 1. The paint manufacturer and product key number
 - 2. Manufacture batch lot number
 - 3. Color
 - 4. Directions and instructions for storage and field touch-up application
- F. Contractor shall supply five gallons of primer and five gallons of each color of paint to the Owner for later use.

2.2 PAINTING PROCESS

- A. Painted surfaces shall have a minimum three-coat application. The coating shall consist of a primer, intermediate, and finish layer, each with a minimum dry 1.5 mil thickness. The total paint thickness shall not be less than 5 mils dry (excluding galvanizing) and shall be in accordance with the paint manufacturer's instructions.

PART 3 - EXECUTION

3.1 INSPECTION

- A. All paint and its application shall be subject to inspection by the Engineer.

3.2 INSTALLATION

- A. Painted surfaces shall receive a minimum of three coats.
- B. Unless otherwise recommended by the paint manufacturer, all paint applications shall be performed when the ambient temperature is between 45 degrees Fahrenheit and 95 degrees Fahrenheit. All paints shall be applied only to surfaces that are completely dry, clean, and free of surface moisture, dirt, dust, oil, mill scale, and detrimental coatings which will cause the paint to lose its bonding properties. The Contractor shall follow all requirements and suggestions provided by the paint manufacturer. Solvent clean all surfaces prior to the application of the prime coat. After 1 week, spot test the paint adhesion to the galvanizing to insure a permanent bond. Brush blast clean the entire galvanized surface if paint test proves unacceptable, in accordance with the paint manufacturer's recommendations.
- C. Items not to be painted, which are in contact with or adjacent to surfaces scheduled for painting, shall be removed or protected prior to surface preparation and painting operations. All masking and protective tapes shall be totally removed, without leaving residue, upon completion of the painting operations. Paint shall not be applied to any insulators, cable insulation, or other OCS components that are not specifically required to be painted.
- D. Prime Coat
 - 1. Primers shall be capable of remaining in satisfactory condition for 6 months without the protection of a finish coat, for all field painting applications.
 - 2. Primers shall have sufficient penetrating and wetting properties to insure good coating regardless of the presence of light scale, or light rust on the surface to be painted.
- E. Intermediate Coat
 - 1. The intermediate coat shall be of a composition similar to the final finish coat, as recommended by the paint manufacturer.
- F. Finish Coat.
 - 1. The finish coat shall be a coating suitable for protecting the surfaces to which it is applied. It shall completely hide the primer and intermediate coats and shall have no visible streaks, blisters, large runs, or obvious color or surface imperfections.
 - 2. Drying time to a tack free condition shall not be more than 24 hours.

3.3 APPLICATION

- A. Paint shall be factory applied by dip, spray, or electro-coating except as herein specified. Field touch-up painting shall be by clean, dry brush or roller application, in accordance with paint manufacturer's instructions. At the time of application, all paint mixes shall show no signs of deterioration and be thoroughly mixed prior to applying. Powder coating over hot-dipped galvanizing shall be considered acceptable, pending demonstration of its in-service performance and application and shall be approved by the Engineer prior to manufacture.
- B. Paints of different manufacturers shall not be mixed together. Thinning is acceptable prior to application where necessary to suit conditions of surface, temperature, weather and method of application with not more than one pint of approved thinner per gallon of paint or as per the paint manufacturer's instructions.
- C. Paint shall be applied so the final finished surfaces shall be free of visible runs, drops, blisters, brush marks, and variation of color, texture, and finish.
- D. Each coat shall be applied as a film of uniform thickness, not less than 1.5 mils dry. Special attention shall be given to insure that all surfaces including edges, corners, crevices, welds, voids, and base plates receive a film thickness equivalent to that of adjacent painted surfaces.
- E. Sufficient time shall elapse between successive coats to permit proper drying. The application of another coat shall not cause the lifting or loss of adhesion of the undercoat.

3.4 FIELD QUALITY CONTROL

- A. All painting activities shall be in accordance with these Specifications, and are subject to inspection at any time by the Engineer.
- B. All paint which is unacceptable as applied, shall be removed or repaired in accordance with the paint manufacturer's instructions, and inspected for Approval by the Engineer at the Contractor's expense.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification
SECTION 34 23 37
OCS TUBULAR STEEL POLES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section covers furnishing, fabrication, hot-dip galvanizing, hard marking, labeling, and delivery of new tapered tubular steel poles and accessory parts, for use as part of the Overhead Contact System (OCS) as shown on the Contract Drawings.
- B. The Contractor shall fabricate all OCS tapered tubular steel poles per the Contract Drawings.
- C. There will be 5 general configurations of OCS poles on the project; sole use OCS poles, OCS poles with street lighting, OCS feeder poles, Ornamental OCS poles, and OCS poles with traffic signal accessories. In some cases there will be combinations of these configurations. OCS pole finish may vary on the project, possibly utilizing both galvanized and painted finishes. The Contractor shall verify OCS pole types and finishes with the Engineer prior to procurement. See Sections 34 23 37 OCS Tubular Steel Poles, 34 23 37.11 OCS Pole Ornamentation, 34 23 35.99 OCS Pole Painting, and the Texas Department of Transportation Governing Specifications and Special Provisions for related Specifications. OCS poles shall be procured based on these Specifications and Contract Drawings, in conjunction with Approval from the Engineer.
- D. A summary of the possible pole combinations is provided below.
 - 1. Regular (Non-Feeder) OCS poles may be ornamental or simple tubular. They may also be combined with lighting or traffic accessories.
 - 2. OCS Feeder poles will be simple tubular poles with spouts. Feeder poles will not be ornamental poles. Feeder poles will not be combined with lighting or traffic accessories.

1.2 RELATED SECTIONS

- A. SECTION 01 33 00 – Submittal Procedures
- B. SECTION 01 43 00 – Quality Control Requirements
- C. SECTION 34 23 35.99 – OCS Pole Painting
- D. SECTION 34 23 37.11 – OCS Pole Ornamentation
- E. Specifications for Street Lighting Attachments on OCS Poles shall be in accordance with Texas Department of Transportation Governing Specifications and Special Provisions, in conjunction with Approval from the Engineer.
- F. Specifications for Traffic Signal Attachments on OCS Poles shall be in accordance with Texas Department of Transportation Governing Specifications and Special Provisions, in conjunction with Approval from the Engineer.

1.3 REFERENCE STANDARDS

- A. The latest edition of the following reference specifications shall also govern the Work covered by this Section unless otherwise noted.
 - 1. ASTM A36 Structural Steel
 - 2. ASTM A53 Pipe, Steel, Black and Hot-dipped, Zinc Coated, Welded and Seamless

- | | | | |
|-----|----------|------------|---|
| 3. | ASTM | A123 | Zinc Coating (Hot-Dip Galvanized) on Iron and Steel Products |
| 4. | ASTM | A153 | Zinc Coating (Hot-Dip) on Iron and Steel Hardware |
| 5. | ASTM | A325 | High Strength Bolts for Structural Steel Joints. |
| 6. | ASTM | A370 | Mechanical Testing of Steel Products |
| 7. | ASTM | A449 | Specification for Quenched and Tempered Steel Bolts and Nuts |
| 8. | ASTM | A500 | Specification for Circular cross-section Tubular Pole ($F_y = 42$ ksi) |
| 9. | ASTM | A563 | Carbon and Alloy Steel Nuts |
| 10. | ASTM | A572 | High Strength Low-alloy Columbium- Vanadium Steels of Structural Quality |
| 11. | ASTM | A595 | Steel Tubes, Low Carbon, Tapered for Structural Use |
| 12. | ASTM | E269 | Standard Definitions of Terms Relating to Magnetic Particle Examination |
| 13. | ASTM | E709 | Standard Recommended Practice for Magnetic Particle Examination |
| 14. | ASTM | F436 | Hardened Steel Washers |
| 15. | ASTM | F593 | Stainless Steel Bolts, Hex Cap Screws and Studs |
| 16. | AISC | | Code of Standard Practice for Buildings and Bridges |
| 17. | AISC | | Manual of Steel Construction |
| 18. | AWS | D1.1 | Structural Welding Code - Steel |
| 19. | ASNT | SNT-TC-1A | Personnel Qualifications and Certification in Nondestructive Testing |
| 20. | MILSPEC | | DOD-P-21035 Paint, High Zinc Dust Content Galvanizing Repair |
| 21. | FED SPEC | FF-T-79166 | Type 1 Form 1 Hot-Dip Galvanized Drop Forged Steel Quenched and Tempered Hardware |

1.4 SUBMITTALS

- A. Submittals shall be made in accordance with the requirements of SECTION 01 33 00 except as modified herein:
1. The Contractor shall submit the specifications for welding procedures and processes, certificates of qualifications of welders, welding operators, tackers, and welding inspectors for acceptance.
 2. The Contractor shall submit for review shop drawings of all pole types required. The shop drawings shall be to scale, giving complete information necessary for the fabrication of the poles. The drawings shall also indicate all fittings, holes, and accessories. The locations, sizes and types of all welds shall also be included on the drawings.
 3. The Contractor shall submit for review, prior to commencing fabrication, the manufacturer's certificates of compliance, or certified laboratory test reports. The reports shall demonstrate the compliance of all raw materials and fabrication products. Included shall be a listing of all standards designated by the manufacturer, as indicated.

4. The Contractor shall furnish copies of test reports of all factory tests as required by these specifications and referenced standards.

1.5 QUALITY CONTROL/QUALITY ASSURANCE

Quality control activity shall be in accordance with SECTION 01 43 00 except where varied herein:

- A. Qualifications for welding work
 1. Quality of welding processes and welding operations shall be in accordance with current AWS D1.1.
 2. Provide certifications that welders employed have satisfactorily passed AWS qualification per current AWS requirements.
- B. Source Quality Control: Material and fabrication procedures are subject to inspections and tests in the mill, shop, and field. These inspections and tests shall not relieve the Contractor of the responsibility for providing materials and fabrication procedures that are in compliance with the requirements.
- C. Shop Assembly: Preassemble components in the shop to the maximum extent possible. In order to simplify field assembly of units, clearly mark components for easy assembly at the site of installation.
- D. Material Testing: The chemical compositions and appropriate mechanical properties shall be determined for all materials used, either by obtaining manufacturer's certificates of compliance or by laboratory testing at a facility which is acceptable to the Engineer.
- E. Weld Testing
 1. The services of an AWS Certified Welding Inspector shall be provided by the Fabricator to perform specified fabrication and verification inspection of welding procedures and personnel, and to perform weld tests as specified herein. Approval of the Welding Inspector shall be obtained from the Engineer.
 2. A visual inspection of all welds shall be performed in conformance with the AWS code.
 3. Weld testing shall be performed on a sample number of poles selected at random by the Engineer, comprising 20% of the total number of poles.
 4. Equipment, procedures, personnel for weld testing, and test reports shall conform to the requirements of AWS D1.1, Section 6 - Inspection.
 5. Weld testing shall consist of:
 - a. Ultrasonic testing conforming to the requirements of AWS D1.1, section 6
 - b. Magnetic particle testing conforming to the requirements of ASTM E709
 6. The pole selected for testing shall be tested by the ultrasonic and magnetic particle methods.
 7. Ultrasonic testing shall be performed on the complete penetration welds between the pole shaft and pole base, and on any circumferential welds in the pole shaft, for each pole being tested. Magnetic particle testing shall be performed on all other welds including longitudinal seam welds, welds at handholes, etc.
 8. For each tested pole that is found to be deemed unacceptable, weld testing shall be performed on another sample pole selected at random by the Engineer.
 9. Results of weld testing shall be deemed acceptable or unacceptable in accordance with AWS D1.1, sections 8, 9 or 10.

10. Welds found to be unacceptable shall be repaired as specified, and retested at the Contractor's expense.
- F. Impact Testing: Structural steel materials for base plates and pole shafts shall be tested for impact toughness in accordance with the Charpy V-notch test as specified in ASTM A370. The minimum energy value shall be 15 ft-lbs at 0°F.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. During fabrication and delivery, steel products shall be handled and transported in a manner that will prevent damage occurring to the structural steel, galvanizing, and surface coatings.
- B. Material shall not be stored in contact with the ground. It shall be stored in a manner and location that will not cause deterioration of the material.
- C. Any damage to the material and equipment shall be the Contractor's responsibility and all repairs shall be accomplished by the Contractor in accordance with the manufacturer's instructions, at the Contractor's expense.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. OCS Tapered Tubular Steel Poles
 1. Tapered tubular steel poles shall be furnished complete with base plate, pole shaft, stiffeners, handholes, feeder spouts, and fittings.
 2. Poles shall be single or double ply.
 3. Poles shall be fabricated with the pole shaft having a circular cross section.
 4. Pole shafts shall be fabricated from one structural steel material type conforming to the following ASTM Specification:
 - a. Multiple Faceted or Circular cross section Tapered Tubular Pole including Joint Use Poles – A572 and/or A595.
 5. Base Plates: Base plates shall be procured or fabricated from structural steel conforming to one of the following Specifications:
 - a. ASTM - A572, Grade 50 steel.
 - b. ASTM – A633, Grade 50 steel.
 6. Poles shall have no spliced joints.
 7. Pole Attachments
 - a. Pole and handhole reinforcements shall be fabricated from steel of the same grade as specified for the pole shafts.
 - b. Feeder spouts (outlets) shall be standard steel pipe conforming to ASTM A53, Type S, Grade B.
 - c. Pole caps shall be fabricated from steel compatible with the pole shaft, and fitted with three stainless steel set screws.
 - d. Handhole cover screws shall be stainless steel hex head set screws.
 - e. Lighting attachments will require holes through the pole shaft to accommodate wiring.

8. Weld filler shall be selected in compliance with the welding procedures of AWS D1.1 and shall be capable of producing satisfactory designed strength.
9. All steel shall be handled carefully to keep it clean, and it is to be treated with the care and concern that should be to any product whose finished surfaces are to remain as prepared in the shop. The steel shall be kept free and clean of all foreign matter that may affect the natural oxidation of the steel. The Contractor shall immediately remove any foreign matter found on the steel.
10. Hot-dip galvanizing shall be in accordance with ASTM A123 for fabricated pole assemblies and ASTM A153 for hardware.
11. Miscellaneous structural steel shall conform to ASTM A36.

2.2 FABRICATION

- A. General: Poles, base plates, and fittings, including handholes, grounding lugs, "J" hooks and base partition accessories shall be fabricated to the dimensions indicated on the Contract Drawings or the Contractor's OCS Pole design shop drawing, as approved by the Engineer.
- B. Methods: Poles, fittings, accessories, and base plates shall be fabricated by methods conforming to AISC Specifications, except as specified herein.
- C. Welding Procedures: Welding procedures, welders, welding operations, and tackers shall conform to the provisions of the current AWS D1.1, Section 2, Design of welded connections; Section 3, Workmanship; Section 4, Techniques; and Section 8, 9 or 10.
- D. Preheat: Preheat base plate immediately prior to welding pole shaft to base plate.
- E. Weld Repair: Welds found to be unacceptable shall be repaired in accordance with the provisions of AWS D1.1, Section 3, Workmanship.
- F. The connections shall be welded in accordance with the Contract drawings and shall be fabricated in the shop, using E70xx electrodes in compliance with the welding procedures of AWS D1.1.
- G. Allowable Tolerances are as follows:
 1. Tubular pole diameter shall be within 1/16 inch of the design diameter, and shall be within 1/16 inch measured by girthing.
 2. Pole wall thickness shall be within plus 10%, but no less than the design thickness.
 3. Pole straightness shall be within 1/8 inch per 5 feet of pole length.
 4. Tolerances for base plates shall be as follows:
 - a. Bolt Circle Diameter: + 1/16 inch
 - b. Hole Diameter: + 1/16 inch,
 - c. Location of Holes: + 1/16 inch in each direction
- H. Pole Type Identification Number is used to identify the pole type and shall be stamped in 1-inch high letters by a minimum 1/16 inch deep in the vertical edge of the base plate before galvanizing. Pole Type Identification Number shall be applied to the opposite side from the handhole. Pole Type Identification Numbers shall be clearly readable after galvanizing.
 1. Pole Type Identification Numbers shall match the designations on the pole assembly drawings.
- I. For ornamental bases, cladding, globe arms, accessories and connections see SECTION 34 23 37.11 – OCS Pole Ornamentation.

- J. Street Lighting Attachments on OCS Poles shall be in accordance with Texas Department of Transportation Governing Specifications and Special Provisions, in conjunction with Approval from the Engineer.
- K. Traffic Signal Attachments on OCS Poles shall be in accordance with Texas Department of Transportation Governing Specifications and Special Provisions, in conjunction with Approval from the Engineer

2.3 FACTORY TESTING

- A. Poles shall be factory tested according to the provisions in SECTION 34 23 80 – OCS Testing.

PART 3 - EXECUTION

Not Used

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification
SECTION 34 23 37.11
OCS POLE ORNAMENTATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Work of this Section includes furnishing ornamental catenary pole bases, cladding, globe arms, and accessories as shown on the Contract Drawings and as specified herein.
- B. Ornamental pole bases, cladding, globe arms, and accessories shall be dimensioned as shown on OCS drawings in Contract Drawing Set, and to fit pole types specified in these Specifications, or on individual poles nominated on OCS Foundation and Pole Schedule drawings.
- C. Ornamental poles shall match El Paso's ornamental street lighting poles along the alignment and be approved by the City Engineer.

1.2 RELATED SECTIONS

- A. SECTION 01 33 00 – Submittals
- B. SECTION 01 43 00 – Quality Control Requirements
- C. SECTION 34 23 37 – OCS Tubular Steel Poles
- D. Specifications for Street Lighting Attachments on OCS Poles shall be in accordance with Texas Department of Transportation Governing Specifications and Special Provisions, in conjunction with Approval from the Engineer.
- E. Specifications for Traffic Signal Attachments on OCS Poles shall be in accordance with Texas Department of Transportation Governing Specifications and Special Provisions, in conjunction with Approval from the Engineer.

1.3 REFERENCES

- A. ASTM A 36 Specifications for Structural Steel
- B. AWS -- American Welding Society
- C. CDA -- Copper Development Association
- D. SSPC -- Paint 12 Steel Structures Painting Council Paint Specification No. 12 Cold Applied Asphalt Mastic (Extra Thick Film)

1.4 PERFORMANCE REQUIREMENTS

- A. Prevent galvanic action and other forms of erosion by insulating metals and other materials from direct contact with incompatible materials.

1.5 SUBMITTALS

- A. Submittals shall be made in accordance with the requirements of SECTION 01 33 00 – Submittals.
- B. Submit manufacturer's specifications, anchor details, installation instructions and finishes for products to be used in the fabrication of ornamental catenary pole bases, cladding, globe arms, and accessories.

- C. Submit shop drawings showing fabrication and installation of ornamental catenary pole bases, cladding, globe arms, and accessories; including plans, elevations, details of components, and attachments to other units of Work. Indicate Materials and profiles of each ornamental metalwork member, fitting, joinery, finishes, fasteners, anchorage, and accessory items.

1.6 QUALITY CONTROL

- A. Quality control shall be in accordance with the requirements of SECTION 01 43 00 – Quality Control Requirements, except as modified herein.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Ornamental catenary pole bases, cladding, globe arms, and accessories

2.2 WELDING MATERIALS, FASTENERS, AND ANCHORS

- A. Anchors for metal components shall be of same basic material as the metal.
- B. Shop-weld corners and seams continuously, complying with AWS recommendations.
- C. Grind welds exposed in finish work smooth, flush and polished, to match and blend with adjoining surfaces.
- D. Use fasteners of same basic metal as the fastened metal, unless otherwise indicated. Do not use metals that are corrosive or incompatible with materials joined.

2.3 FABRICATION

- A. The ornamental catenary pole bases, cladding, globe arms, and accessories shall be constructed from a thermoset resin (either urethane or polyester preferred) with UV stabilizers. The ornamental catenary pole bases, cladding, globe arms, and accessories shall be coated with a UV resistant coating and shall be manufactured with through-the-wall color compatibility with the final surface coloring. The ornamental catenary pole bases, cladding, globe arms, and accessories shall be constructed to form two primary mating parts.
- B. The two primary ornamental catenary pole bases, cladding, globe arms, and accessories parts shall be connected to each other at sufficient locations to maintain alignment of the mating surfaces. As a minimum, four connection locations shall be provided; two near the top portion of the base and two near the bottom portion of the base at each side. All fastener hardware shall be either hot dip galvanized or stainless steel. The entire ornamental catenary pole bases, cladding, globe arms, and accessories shall be capable of removal and reinstallation from the pole without damage and without the removal or disconnection of other pole features, fixtures or assemblies. The ornamental catenary pole bases, cladding, globe arms, and accessories shall be flexible in nature, hardness approximately Shore D60, so that they resist cracking or chipping when subjected to impact loads (i.e. paint may chip, but base is resilient).
- C. The ornamental catenary pole bases, cladding, globe arms, and accessories shall be tested for fit before commencing mass manufacture.

PART 3 - EXECUTION

Not Used

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 34 23 40 OCS WIRE AND CABLE

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section covers procurement and installation of wire and cable for OCS use within the OCS associated with the streetcar system route and project as described in SECTION 34 23 10 – OCS Description and General Requirements.
- B. Work under this Section includes the procurement of wire conductors and insulated cable for use as part of the installation of OCS equipment in accordance with OCS Wiring Layout Drawings, OCS Wiring Schedules, Traction Electrification Sectionalizing Diagrams, and Standard OCS System Drawings contained in the Contract Drawings.
- C. The wire to be procured and installed includes bare wire conductors used as OCS contact wire, bare feeder wires, bare jumper wires, feeder cables, jumper cables, terminations, ground wires, and all other OCS associated components
- D. The cable to be procured and installed includes insulated conductors used as feeders, or jumpers electrically connecting and passing current, either directly or indirectly from the outgoing terminal of pole mounted switches to the operational contact wire of the OCS.

1.2 RELATED SECTIONS

- A. DIVISION 01 – General Requirements
- B. SECTION 26 – Traction Power Specifications
- C. SECTION 34 23 10 – OCS System Description and General Requirements
- D. SECTION 34 23 50 – OCS Assemblies, Components and Fittings
- E. SECTION 34 23 70 – OCS Installation
- F. SECTION 34 23 80 – OCS Testing

1.3 REFERENCED STANDARDS

- A. ASTMB1 Hard-Drawn Copper Wire
- B. ASTMB8 Concentric Lay Stranded Copper Conductors - Hard, Medium Hard, or Soft
- C. ASTMB47 Copper Contact Wire

1.4 SUBMITTALS

- A. Submittals shall be made in accordance with the requirements of SECTION 01 33 00 of the Contract Documents, except as modified herein.
- B. Contact Wire
 - 1. Submit certification verifying that the Contact wire has been designed, manufactured, inspected, and tested in accordance with the referenced standards and these specifications.
 - 2. Submit complete manufacturer's data.

C. Jumper Wire

1. Submit certification verifying that the Jumper wire has been designed, manufactured, inspected, and tested in accordance with the referenced standards and these specifications.
2. Submit complete manufacturer's data.

D. Feeder and Feeder Jumper Cable

1. Submit certification verifying that the Feeder Cable and Feeder Jumper Cable has been designed, manufactured, inspected, and tested in accordance with the referenced standards and these specifications.
2. Submit complete manufacturer's data.

E. Samples

1. Submit three 1-inch long samples of each conductor or cable to the City Engineer.
2. Cables shall have ends secured from fraying.
3. All samples shall have rough edges at ends filed down.
4. All samples shall be labeled with wire tape and intended use clearly identified.

1.5 QUALITY ASSURANCE/QUALITY CONTROL

- A. Quality Control/Quality Assurance shall be in accordance with SECTION 01 43 00 except where modified within this Specification Section.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Assembly, component, and fitting materials shall be packaged, stored, handled, and transported in a manner that will prevent damage occurring to the material and any surface coatings.
- B. Wire and cable materials shall be carefully wound onto drum built suitably for that wire or cable. Where wire or cables being supplied may form part of the Owner's maintenance stocks, cable drums shall be manufactured from steel.
- C. Materials shall not be stored in contact with the ground. It shall be stored in a manner and location that will not cause deterioration of the material. It shall be labeled clearly and numbered to match the Contractor's approved design drawings.
- D. Any damage to the materials and equipment shall be the Contractor's responsibility, and all repairs shall be accomplished by the Contractor in accordance with the manufacturer's instructions, at the Contractor's expense.

PART 2 - PRODUCTS

2.1 CONTACT WIRE

- A. The contact wire shall be solid grooved hard drawn copper. The contact wire shall conform to or exceed the requirements of ASTM B47. The contact wire size shall be 350kcmil.
- B. The contact wire shall be wound on reels, with its vertical axis normal to the barrel of the reel. The wire shall be wound evenly, tightly, and with no kinks. The diameter of the reel spindle shall be large enough to prevent excessive wire twist when running the wire out of the reel. A minimum diameter of 36 inches is permitted.

2.2 JUMPERS

- A. Full current and potential equalizing jumpers shall be 350 kcmil stranded, annealed copper cable conforming to ASTM B3 and B8 Class G or H, bare. The connections to the conductors shall be of copper or bronze.

2.3 INSULATED FEEDER CABLE AND FEEDER JUMPERS

- A. Feeder cables and feeder jumpers shall be 250 kcmil 2000 V insulated copper cable.
- B. The size of feeder wire to be installed at each location shall be as shown on the sectionalizing schematic drawings in the Contract.

2.4 GROUND CABLES

- A. OCS Pole and Surge Arrester Ground cable sizes shall be as shown in the Drawings, unless otherwise specified.
- B. OCS Pole and Surge Arrester Ground methods shall be in accordance with the Contract Drawings, these Specifications, and SECTION 26 05 26 – Grounding and Bonding.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation of wires shall be per the Contract Drawings and SECTION 34 23 70 – OCS Installation, of these Specifications.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 34 23 50 OCS ASSEMBLIES, COMPONENTS, AND FITTINGS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section covers the provision of assemblies, components, and fittings that make up the OCS for the streetcar system, as described in SECTION 34 23 10 – OCS Description and General Requirements.
- B. Work under this Section includes the provision of OCS equipment in accordance with the OCS Wiring Layout Drawings, Assembly Drawings, Pole and Foundation Schedules, and other related Drawings contained in the Contract Drawings.
- C. The equipment to be provided includes items associated with cantilevers, headspans, cross-spans, conductor support assemblies, feeder and jumper components, terminations, sectioning equipment, disconnect switches, surge arresters, and other components required for the complete installation of the OCS for the route and maintenance shop.
- D. All OCS equipment is energized at a nominal 600 V DC, and shall be double insulated. A minimum of two levels of electrical insulation shall be provided between the contact wire and a line pole or other grounded structure
- E. All OCS assemblies, components, and fittings shall be designed and manufactured in accordance with SECTION 01 43 00 except where modified within this Specification Section.
- F. All OCS assemblies, components, and fittings shall be submitted to the Engineer for Approval, in accordance with Section 01 33 00.
- G. Installation of Assemblies, components and fittings shall be per SECTION 34 23 70 – OCS Installation.

1.2 RELATED SECTIONS

- A. DIVISION 01 – General Requirements
- B. SECTION 34 21 50 – DC Surge Arresters
- C. SECTION 34 23 10 – OCS System Description and General Requirements
- D. SECTION 34 23 40 – OCS Wire and Cable
- E. SECTION 34 23 70 – OCS Installation
- F. SECTION 34 23 77 – Surge Arrester Installation
- G. SECTION 34 21 78 – Disconnect Switch Installation
- H. SECTION 34 23 80 – OCS Testing

1.3 REFERENCED STANDARDS

- A. The pertinent provisions of the latest revisions of the codes and standards of the applicable NEMA, IEEE and ANSI shall apply to the Work of this Section.

1.4 SUBMITTALS

- A. Submittals shall be in accordance with the requirements of SECTION 01 33 00, except as modified herein.
- B. The Contractor shall submit for review and approval by the Engineer, complete details for all assemblies, equipment, and components specified on the OCS Drawings provided.
- C. The Contractor shall furnish suitable illustrated catalog sheets, sufficient for the identification of all components not bearing individual identification, for all equipment and components not specified in this Section. All components for the OCS shall be submitted as shop drawings or catalog sheets, without exception. The Engineer may request submission of sample components if required for clarification.
- D. All design data, calculations, and design results shall be bound with a Table of Contents and the full volume shall bear the seal of a registered Professional Engineer qualified by experience, who personally supervised the preparation of the design.
- E. The Contractor shall submit test reports from Factory Design Tests and Factory Production Tests specified in SECTION 34 23 80 – OCS Testing.
- F. Disconnect Switches
 - 1. Submit complete manufacturer's descriptions, catalog data, and information including model numbers or serial numbers.
 - 2. Submit manufacturer's general and detail arrangement drawings, and installation instructions.
 - 3. Submit operation and maintenance manuals with a list of recommended spare parts.
 - 4. Submit installation and adjustment procedures.
- G. Stainless Steel Wire Rope
 - 1. Submit certification verifying that the stainless steel wire and wire rope have been designed, manufactured, inspected, and tested in accordance with the referenced standards and these specifications.
 - 2. Submit complete manufacturer's data.
- H. Galvanized Steel Wires
 - 1. Submit reports for each type of wire to be used containing the physical and mechanical properties of all components described in this Section. The conformance of components with these Specifications and Contract Drawings in the form of a manufacturer's certification shall be shown. Include the following as a minimum:
 - a. Size
 - b. Type
 - c. Material
 - d. Number of and diameter of individual wires
 - e. Overall diameter
 - f. Cross-section area
 - g. Weight per foot
 - h. Rated breaking load

2. Submit a certification that the galvanized steel wire and wire rope have been designed, fabricated, rated, and tested in compliance with the applicable provisions of the standards referenced in these Specifications.

I. Wiring Assemblies, Fittings, and Components

1. Submit Shop Drawings for all assemblies, fittings, and components for approval prior to manufacture. Shop drawings shall show details, dimensions, designations of the materials comprising the various components, and shall include technical, mechanical, and electrical characteristics as Specified.
2. Submit samples of certain components as required by the Engineer.

J. Insulators

1. Submit Shop Drawings prior to insulator manufacture, showing details and dimension of the insulating and metal parts, describing the material composing the various parts, together with technical, mechanical, and electrical characteristics.
2. Submit Certificates of compliance as applicable for the following:
 - a. Steel analysis
 - b. Analysis of other copper, bronze, and aluminum materials
 - c. Hot-dip galvanizing
 - d. Adhesive materials
 - e. Insulator materials
 - f. In-service record of proposed insulators
 - g. Certified Quality Control Procedures used in the manufacturing process
3. Submit the follow data prior to insulator manufacture:
 - a. A complete set of assembly, component, and detail Drawings showing dimensions and weights
 - b. Storage and handling instructions
 - c. Test Procedures and Reports as Specified in SECTION 34 23 80 – OCS Testing
 - d. Installation procedures

K. Brackets and Hinges

1. Submit Shop Drawings for all components for approval prior to manufacture, showing details and dimensions, and giving designations of the materials comprising the various components together with technical, mechanical, and electrical characteristics as Specified.
2. Submit samples of certain components as required by the Engineer.
3. Submit installation and adjustment procedures.

L. Surge Arresters

1. Submit Shop Drawings for all components for approval prior to manufacture, showing details and dimensions, and giving designations of the materials comprising the various components together with technical, mechanical, and electrical characteristics as Specified.
2. Submit samples of certain components as required by the Engineer.
3. Submit installation and adjustment procedures.

M. Fixed Terminations

1. Submit Shop Drawings for all components for approval prior to manufacture, showing details and dimensions, and giving designations of the materials comprising the various components together with technical, mechanical, and electrical characteristics as Specified.
2. Submit samples of certain components as required by the Engineer.

N. Warning Signs, I.D. Numbers, and Information Markers

1. Submit Shop Drawings for all components for approval prior to manufacture, showing details and dimensions, and giving designations of the materials comprising the various components together with technical, mechanical, and electrical characteristics as appropriate.
2. Submit samples of certain components as required by the Engineer.

O. Section Insulators

1. Submit Shop Drawings prior to section insulator manufacture, showing details and dimension of the insulating and metal parts, describing the material composing the various parts, together with technical, mechanical, and electrical characteristics.
2. Submit Certificates of compliance for the following:
 - a. Steel analysis
 - b. Analysis of other copper, bronze, and aluminum materials
 - c. Hot-dip galvanizing
 - d. Adhesive materials
 - e. Insulator materials
 - f. In-service record of proposed insulators
 - g. Certified Quality Control Procedures used in the manufacturing process
3. Submit the follow data prior to insulator installation:
 - a. A complete set of assembly, component, and detail Drawings showing dimensions and weights
 - b. Storage and handling instructions
 - c. Test Procedures and Reports as Specified in SECTION 34 23 80 – OCS Testing
 - d. Installation procedure
4. Submit details of any specifications for materials included in the section insulator assembly which are not covered in this specification.

1.5 QUALITY ASSURANCE/QUALITY CONTROL

- A. Quality Control/Quality Assurance shall be in accordance with SECTION 01 43 00 except where modified within this Specification Section.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Assembly, component, and fitting materials shall be packaged, stored, handled, and transported in a manner that will prevent damage occurring to the material and any surface coatings.
- B. Materials shall not be stored in contact with the ground. It shall be stored in an enclosed place, in a manner and location that will not cause deterioration of the material. It shall be labeled clearly and numbered to match the Contractor's approved design drawings.
- C. Any damage to the materials and equipment shall be the Contractor's responsibility and all repairs shall be accomplished by the Contractor in accordance with the manufacturer's instructions, at the Contractor's expense.

1.7 SAMPLES

- A. Provide samples of the following proposed items, along with a description of its intended use.
 - 1. All conductor clamps to be used including contact wire clamps.
 - 2. Insulators
 - 3. All other assemblies, fittings, and components as requested by the Engineer

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. OCS assemblies, fittings, and components shall be standard products of manufacturers regularly engaged in the production of such materials and equipment, and shall be the manufacturers' latest proven design.
- B. Contractor shall size all components to meet all site specific loading requirements, in combination with required factors of safety as Specified in SECTION 34 23 10 – OCS System Description and General Requirements.
- C. Contractor shall provide components capable of withstanding the project environment without degradation or loss of function.
- D. Products to be purchased shall be identified by the Contractors and quantified in the Bill of Materials Schedule. The Contractor shall make allowances for waste and breakages.
- E. Materials and equipment shall be delivered to the job site in unbroken packages, reels, or other forms of containers.
- F. Materials and equipment shall be stored in a manner that will prevent damage or degradation. Any materials deemed by the Engineer to be damaged shall be replaced at the cost of the Contractor.

2.2 BRACKETS AND HINGES

- A. Brackets, pole wraps, and pole bands with hinges as shown on the Contract Drawings shall be used to attach bracket arms, cross-spans, headspans, cantilevers, pull-offs, and terminations.
- B. The maximum breaking strength, or maximum working strength with corresponding factor of safety of all brackets, pole wraps, and pole bands with hinges shall be shown in shop drawings and catalog cuts.

- C. Contractor shall size all brackets, hinges, and related components as required by loading and Specified component factor of safety, as given in SECTION 34 23 10 – OCS System Description and General Requirements.
- D. Specific bracket sizes shall correspond to specific tapered tubular pole sizes.
- E. Brackets that are simple and small, but have the required strength are desirable.

2.3 WIRE PULL-OFF AND BACKBONE ASSEMBLIES

- A. Direct pull-offs shall be suitable for single and multiple track operations.
- B. Pull off and backbone assemblies shall be used to hold the OCS system in its correct alignment on curves.
- C. The Contractor shall design and specify tensions and attachment heights of overhead guying and backbones including bridles and pull offs where required. Contractor shall size all wire, clamps, and components as required by loading and Specified component factor of safety, as given in SECTION 34 23 10 – OCS System Description and General Requirements.
- D. Suitable bull-rings may be used in backbone systems to achieve correct tension distribution and accommodate the angles required. If bull-rings are not used, the fittings utilized shall not cause kinking or detrimental stresses in the backbone wire.
- E. Pull-off and Backbone assemblies shall not infringe upon the pantograph envelope.
- F. Stainless Steel wire shall be used for pull off and backbone assemblies.
- G. The pull offs shall be designed to accommodate the loads at each location, and shall maintain a minimum load of 200lb in all locations along the pull off wire at any temperature or condition.

2.4 HEADSPANS

- A. Headspans shall consist of two or more steel span wires with double insulation. The span wires shall include insulators, where required, and turnbuckles with a minimum of 6 inches of adjustment capability, in each direction, after installation.
- B. Contractor shall size all wire, clamps, and components as required by loading and Specified component factor of safety, as given in SECTION 34 23 10 – OCS System Description and General Requirements.
- C. Headspan assemblies shall not infringe upon the pantograph envelope.
- D. Headspan geometry shall be in accordance with SECTION 34 23 10 – OCS System Description and General Requirements.
- E. Stainless Steel wire shall be used for headspans.

2.5 CROSS-SPANS AND SPAN GUYS

- A. Cross-spans shall consist of a single steel wire with double insulation. Cross-spans and span guys shall be designed for single and multi-track arrangements. The cross-span and span guy wires shall be easily adjustable with turnbuckles to facilitate installation, adjustment, and future maintenance, and shall have at least 6 inches of adjustment in each direction, after installation.
- B. Contractor shall size all wire, clamps, and components as required by loading and Specified component factor of safety, as given in SECTION 34 23 10 – OCS System Description and General Requirements.
- C. Cross-span and span guy assemblies shall not infringe upon the pantograph envelope.

- D. Cross-span geometry shall be in accordance with SECTION 34 23 10 – OCS System Description and General Requirements.
- E. Stainless Steel Wire shall be used for Crossspans.

2.6 WIRE TERMINATION FITTINGS

- A. Strain type termination assemblies shall be of a straight line design or of other design of aesthetically pleasing appearance.
- B. Wire wrap, cone, or wedge type designs are acceptable, and turnbuckles with a minimum of 6 inches of adjustment capability in each direction after installation shall be included. Slip strength of the assembly shall meet 100% of the breaking strength of the terminating conductor.

2.7 PIPE

- A. Application
 - 1. Pipe is generally used for constructing support assemblies, and can be made from various materials.
 - 2. The cut ends of pipe shall be painted, plugged or capped for protection and appearance.
- B. Standard Sizes
 - 1. ASTM A53 Grade B steel pipes are standard. The following types are commonly used, however the Contractor is responsible for determining appropriate size and schedule of pipe, based on all site specific loadings and structural Specifications provided in SECTION 34 23 10 – OCS System Description and General Requirements.
 - a. Steady arms are generally made of $\frac{3}{4}$ inch diameter schedule 40 or schedule 80 pipes.
 - b. Cantilever frames are generally made of 2 inch diameter schedule 40 or schedule 80 pipes.

2.8 WIRE AND CABLE

- A. Galvanized Steel Wire and Wire Rope
 - 1. Galvanized steel wire and wire rope shall not be used on the Project unless specifically approved for each application by the Engineer.
 - 2. The physical properties of the zinc coated stranded wire shall conform to the description in Table 1 of ASTM A475.
 - 3. The weight of coating for zinc coated steel wire shall not be less than that specified in Table 4, under Class C of ASTM A475.
 - 4. The materials shall be protected against damage during shipping and shall be wound on suitable reels. Each reel shall have a strong weatherproof tag attached which shall show the physical and mechanical properties, the steel type and ASTM designation and the name and mark of the manufacturers.
- B. Stainless Steel Wire and Wire Rope
 - 1. Stainless steel wire rope shall be extra flexible.
 - 2. Stainless steel wire strand shall be manufactured and tested in accordance with the requirements of ASTM standards A368, A555, and A580.
 - 3. Stainless steel wire rope shall be manufactured and tested in accordance with the requirements of ASTM standards A368, A492, A555, and A580.

2.9 SECTION INSULATORS

- A. Bridging type section insulators shall permit continuous current collection during the passage of a vehicle pantograph, and be suitable for mainline train operations.
 - 1. Bridging section insulators supplied by the contractor shall be Arthur Flury AG type or approved equal.
 - 2. Section insulators shall be installed in accordance with manufacturer's instructions.
 - 3. Section insulators shall provide smooth passage of the vehicle pantograph with minimum current interruption by pantographs at running speeds up to 35 mph.
- B. Non-Bridging type section insulators shall ensure that adjacent sections of the OCS will remain electrically isolated from each other during all phases of the passage of a vehicle pantograph.
 - 1. Section insulators shall be installed in accordance with manufacturer's instructions.
 - 2. Non-bridging section insulators shall provide smooth passage of the vehicle pantograph with minimum current interruption by pantographs at running speeds up to 20 mph.
 - 3. The non-bridging gap between adjacent electrical sections shall be 18 inches minimum.
- C. All section insulators shall meet or exceed the following design requirements:
 - 1. All Section Insulators will be submitted to the Engineer for Approval.
 - 2. Test Procedures and Reports, as Specified in SECTION 34 23 80 – OCS Testing, shall be submitted for all Section Insulators.
 - 3. Section Insulators shall meet the load requirements given in the Contract Drawings with the appropriate factors of safety as Specified in SECTION 34 23 10 – OCS Description and General Requirements.
 - 4. Section Insulators shall meet the electrical requirements Specified for Insulators, in Section 2.13 below.
 - 5. The design shall be suitable for use by new pantograph carbons and by carbons with 1 inch of uneven wear.
 - 6. The design shall ensure that electrical isolation between adjacent electrical sections is maintained at all times.
 - 7. The section insulator shall be designed to remain stable dynamically and structurally, under train operating conditions as specified.
 - 8. The section insulator shall be designed to withstand crosswinds of up to 90 mph without failure or permanent deformation.
 - 9. The design shall ensure that the moving pantograph is continuously in contact with the section insulator.
 - 10. Pantographs drawing current while traversing the section insulator shall not cause excessive arcing or damage to the section insulator or pantograph.
 - 11. The design shall allow for torsional forces resulting from the passage of pantographs at rated speed combined with lateral wind loads.
 - 12. Contact wire skids or runners shall be copper or copper alloy and shall provide a smooth transition from one section to another.

2.10 SURGE ARRESTERS

- A. DC surge arresters shall be outdoor style, intermediate class, and shall be designed, constructed and tested in accordance with the general requirements of ANSI C62.1.1. They shall conduct surges due to lightning strikes, and shall block follow-through current from the substation rectifiers.
- B. Surge arresters shall be submitted to the Engineer for Approval.
- C. Surge arresters shall be per SECTION 34 21 50 – DC Surge Arresters.
- D. Each surge arrester shall incorporate an individual grounding system which may be connected to a ground rod or ground mat by means of 4/0 AWG copper wire with a 2000 volt rated insulation.
- E. Each surge arrester shall be suitable for mounting directly to OCS poles, and shall be supplied with the required accessories.
- F. Surge arresters shall be installed as shown in the Contract Drawings, in conjunction with these Specifications.
- G. Surge arresters shall be installed at:
 - 1. Feeder cable termination points at the OCS
 - 2. Bypass disconnect switch cable terminations at the OCS
 - 3. At locations where the track passes beneath overhead structures
 - 4. At any other locations shown in the sectionalizing diagrams in the Contract Drawings
 - 5. At OCS feed points at the vehicle maintenance facilities

2.11 DISCONNECT SWITCHES

- A. Disconnect switches shall be single or twin two position, single throw, non-load break, non-grounding, non-fusible air switches with arcing horns.
- B. The disconnect switches shall be capable of breaking load currents under emergency conditions. The switches for the mainline shall be of the exposed type and have a minimum continuous rating of 1500 V DC and 2000 amperes.
- C. The disconnect switch blades and contact surfaces shall be silver-coated copper or copper alloy. The line and load side disconnect terminals shall have silver-plated copper buses complying with ASTM B187, to accommodate the number and size of feeder cables as indicated on the Contract Drawings. The switch terminals shall have provisions for NEMA drilled (2 or 4 hole) cable terminal lugs.
- D. Separate insulated cable strain posts shall be provided for the termination of cables, designed to prevent cable movements from affecting the adjustment of each switch.
- E. The disconnect switch shall be operated via hot stick.
- F. Each disconnect switch shall be operated using a detachable insulated manual operating handle (hot stick) specifically designed for the purpose. An operating handle will be included with each disconnect switch.
- G. Disconnect switches shall be suitable for mounting on taper tubular, twin ornamental joint use, or wide flange poles.
- H. Disconnect switches shall require approval from the Engineer.

2.12 OCS DOORBRIDGE ASSEMBLY

- A. A special OCS doorbridge assembly is required at each doorway where a roll-up door is installed in a maintenance shop. The roll-up door is typically stored above the lintel of the door, inside the shop.
- B. In order for a roll-up door to close, it is necessary for a short section of the OCS to be retracted out of the path of the door when it closes. The doorbridge provides the means to retract this section of OCS and subsequently, after the door is reopened, to replace the same short section of OCS so the streetcars can enter the shop under their own power with their pantographs raised.

2.13 INSULATORS

- A. The Contractor shall prepare detailed designs for each of the required insulators shown on the Contract Drawings. The designs shall be based on the performance requirements, working loads, required factors of safety as Specified in SECTION 34 23 10 – OCS Description and General Requirements, and basic dimensions. The design shall be submitted for review and Approval by the Engineer.
- B. Insulators shall be suitable for the various assemblies including cantilevers, cross-spans, headspans, registration assemblies, terminations, and any other strain insulator applications. Insulators shall be furnished complete with integral hardware suitable for connection to supports or OCS hardware.
- C. The insulators metal parts shall be made of malleable iron, ductile iron, or forged steel and shall be galvanized, prior to integration to the body in accordance with ASTM A153.
- D. All insulators shall have suitable weathersheds, and all adhesives shall be sealed to the fittings to prevent the ingress of moisture.
- E. All insulators shall have a smooth, void free surface. Unless otherwise directed by the Engineer, color shall match Federal Standard 595A color number 36293 (lusterless medium gray). Color shall be submitted to Engineer for Approval. The insulator shall be capable of withstanding service in the climate described in SECTION 34 23 10 – OCS Description and General Requirements
- F. The design of the insulators shall be such that cyclical stresses due to temperature variation, or other loads including torsion due to contact wire roll, shall not lead to insulation deterioration or mechanical failure.
- G. Insulators shall be porcelain or synthetic, as described below.
- H. Porcelain insulators shall be as follows:
 - 1. The insulator shall be made of the best commercial-grade wet process porcelain in accordance with ASTM D116.
 - 2. The insulator surface shall be free of imperfections. Pieces with imperfections in the glaze repaired by recoating and refiring, as well as pieces repaired by re-touching with paint, will be rejected.
- I. Synthetic insulators may be fabricated from any of the following materials or combinations thereof, depending on type or application:
 - 1. Molded ethylene propylene copolymer with hydrated alumina filler
 - 2. Fiberglass-reinforced epoxy solid rod
 - 3. Composite type with molded ethylene propylene copolymer jacket or skirts formed over a fiberglass-reinforced epoxy core
- J. All insulators shall have the following ratings:

- | | | |
|----|------------------------------|-----------------|
| 1. | Nominal System Voltage | 600 V DC |
| 2. | Insulation Level | 3.7 kV AC RMS |
| 3. | Creepage Distance | 1.88 inch (min) |
| 4. | 60 Hz Withstand Voltage, Dry | 35 kV |
| 5. | 60 Hz Withstand Voltage, Wet | 18 kV |
- K. Each insulator shall also bear the manufacturer's name or trademark and year of manufacture, clearly and permanently imprinted, without affecting the appearance or function of the insulator.

2.14 OCS FITTINGS AND HARDWARE

- A. OCS fittings and hardware includes the following items which, combined with other major items, completes the total OCS.
1. Clevis fittings
 2. Parallel wire and cable clamps
 3. Nuts, bolts, and cotter pins
 4. Wire terminations
 5. Cross-contact assembly
 6. Dead ends
 7. Turnbuckles
 8. Wire splices and connectors
 9. Knuckle assemblies
 10. Links and eyebolts
 11. Thimbles and wire sleeves
- B. All fittings and hardware used for the various OCS assemblies shall be selected and manufactured such that they can be reused after removal.
- C. All fittings and hardware shall be designed to allow an easy interface with the other components of the OCS system.
- D. All fittings and hardware shall be designed and installed in a manner which will provide a homogenous OCS hardware and assembly arrangement.
- E. All components shall be designed such that all fastenings and adjustments are accomplished with the same dimensional standards and tools.
- F. Clevis fittings, nuts, bolts (excluding bolts securing ground cables), turnbuckles, links, eyebolts, thimbles, and wire sleeves shall be hot dipped galvanized, or stainless steel.
- G. Cotter pins shall be stainless steel.
- H. Parallel wire clamps, cable clamps, bolts securing ground cables, wire terminations, dead ends, wire splices, and wire connectors shall be bronze or other copper alloys. Overall OCS design shall ensure the prevention of galvanic corrosion.
- I. Cross-contact assemblies shall be copper, preferably a section of contact wire.

- J. Jumpers shall be double clamped at each end.

2.15 WARNING SIGNS, AND I.D. NUMBERS

- A. Warning signs and pole I.D. numbers shall be supplied and installed by the Contractor.
- B. All signs, and I.D. numbers shall be manufactured for outdoor use. The lettering shall show no appreciable discoloration, cracking, blistering or dimensional changes for a period of ten years.
- C. Pole ID Numbers shall be installed on all poles.

PART 3 - EXECUTION

Not Used

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 34 23 64 OCS SPECIAL TOOLS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section covers furnishing of all special tools required for the OCS work, including but not limited to, jumpers, assembly-specific slings, hoists, special jig and fabrication tools, compression dies, and any other special tools required for working on the Overhead Contact System.
- B. All special tools specified herein and required by the agency shall be purchased as new for this project in coordination with Engineer. The tools may be used by the Contractor and shall remain his property throughout the construction period of the Overhead Contact System, and during its subsequent testing. All special tools shall become the property of the Owner, and shall be delivered to the Owner in good working condition, as directed and Approved by the Engineer.

1.2 RELATED SECTIONS

- A. DIVISION 01 – General Requirements
- B. SECTION 01 33 00 – Submittal Procedures
- C. SECTION 34 23 66 – OCS Spare Parts
- D. SECTION 34 23 70 – OCS Installation

1.3 SUBMITTALS

- A. Submittals shall be made in accordance with the requirements of SECTION 01 33 00, except as modified herein.
- B. Shop drawings and manufacturer catalog cuts shall be submitted showing details and dimensions of all special tools, together with complete specifications of materials proposed for components. The Contractor shall verify the capacity of the tools specified to suit the construction and maintenance needs, and submit their proposal for complete list of tools and tackle for this project for Approval of the Engineer, before procurement.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. All special tools proposed for use shall meet the applicable performance requirements, and shall be non-corroding and durable.

2.2 MANUFACTURED ITEMS

- A. The Contractor shall furnish the following general types of OCS special tools, and manufactured items to the agency, prior to procurement:
 - 1. Manufacturer specific tools (installation, adjustment, maintenance) – two each
 - 2. Shop fabrication jigs (jumpers, and cross contact bridges) – two each
 - 3. Cable thimble, compression and crimp dies and tools – three each
 - 4. Special fastener keys and sockets – three each
 - 5. Safety tools provided with equipment from manufacturers – two each

6. Go/No-Go gauges supplied by manufacturers – two each
 7. Optical Stagger Gauges – two each
 8. Other specialized OCS tools required to install, align, test and commission the catenary and/or components and assemblies – two each
- B. The above special tools are the typical style/purpose tools to be furnished to the Owner. The Contractor shall provide any other special tools required for the installation and maintenance of any other specialized OCS components.
- C. This requirement shall not restrict the Contractor from selecting and providing all necessary tools and equipment to be used by his own crews for the OCS construction.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

- A. The OCS Contractor shall deliver all special tools and products to a location designated by the Engineer, complete and ready for use, subject to the inspection of the Engineer, in sufficient time for all required OCS adjustment purposes.
- B. The OCS Contractor shall be responsible for and protect all products from damage during the duration of the project and shall deliver all special tool items in good working condition to the Owner at the completion of the project. All special tools and equipment required by this Specification that are damaged and rendered useless for this intended purpose, or lost or stolen during the execution of this Contract, shall be replaced by the Contractor at the Contractor's expense.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 34 23 66 OCS SPARE PARTS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the requirements for OCS mandatory spare parts for the El Paso Streetcar project.
- B. Owner may elect to purchase additional spares separately.

1.2 RELATED SECTIONS

- A. SECTION 01 33 00 – Submittal Procedures

1.3 QUALITY ASSURANCE

- A. OCS spare parts shall comply with the requirements of all applicable OCS Specification Sections and shall be in accordance with SECTION 01 43 00 except where modified within this Specification section.

1.4 SUBMITTALS

- A. Unless otherwise specified, all submittals shall be in accordance with SECTION 01 33 00 SUBMITTAL PROCEDURES.
- B. Submit a detailed Mandatory Spare Parts listing with part numbers, manufacturer, and cost for the Approval of the Engineer as part of the Project Shop Drawing and Submittals procedures.
- C. Submit detailed recommended spare parts listed with part numbers, manufacturer, and cost for the approval of the Engineer as part of the project shop drawing and submittal procedures.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Provide the following items to be bid as part of this Contract.
 - 1. All provisioning items shall be identical to the project approved/installed items and shall meet all requirements of the appropriate Sections of these Specifications. Parts availability from the approved supplier to the agency shall be for a period of not less than 7 years after the end of this Contract.
 - 2. All items shall be complete and ready for installation, except for wire or cable and that necessary for connections.

2.2 SPARE PARTS

- A. The following mandatory spare parts shall be furnished as part of the OCS Contract:

1	Cantilever Assemblies (complete assemblies)	
	Push-Off – direct suspension light load	1 Each

	Pull-Off – direct suspension light load	1 Each
	Push-Off – heavy load	1 Each
	Pull-Off – heavy load	1 Each
2.	Cantilever Components	
	Steady Arms – light load	2 Each
	Steady Arms – heavy load	2 Each
3	Section Insulator (bridging)	1 Each
4	Section Insulator (non-bridging)	1 Each
5	Surge Arresters (with mounting hardware)	5 Each
6	Pole mounted disconnect switch (assembly)	2 Each
7	In-Span Contact Wire Insulators and Fittings	4 Each Type
8	Termination Turnbuckles	2 Each
9	Pole Bracket Assemblies	2 Each Type
10	Contact Wire Bridge Assemblies	2 Each
11	Poles	3 of each type
12	Ornamental Poles	3 of each type
13	Contact Wire	1 Drum (5000 feet minimum)
14	Cable (structural)	500 feet of each type of cable used to support OCS
15	Cable (feeder)	500 feet of each type used to electrically feed OCS

- B. Special Tools and Equipment – Provide special tools and equipment as needed for installation, adjustment and testing as specified in SECTION 34 23 64 OCS SPECIAL TOOLS.

PART 3 - EXECUTION

3.1 DELIVERY

- A. Deliver all spare parts to a location directed by the Engineer. Pack all material for warehouse storage and clearly mark with manufacturer's part and/or style number.
- B. Unload and store all items neatly in the Owner's storage facility as directed by the Engineer.
- C. Complete delivery and storage for all spare parts prior to OCS commissioning.

3.2 WARRANTY USE

- A. In the event that any initial provisioning spare part items must be used in the course of satisfying the OCS Contract warranty procedures, the Contractor shall replace such items at the Contractor's expense.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specifications

SECTION 34 23 70 OCS INSTALLATION

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section covers installation of the OCS as described in SECTION 34 23 10 – OCS Description and General Requirements.
- B. Work under this Section includes the assembly and installation of OCS wiring equipment and fittings in accordance with the OCS Wiring Layout Drawings, related drawings contained in the Contract Drawings, and Specifications.
- C. The equipment to be installed includes OCS supports, conductors, feeder jumpers, terminations, sectioning equipment, and all other OCS associated components to create an OCS suitable for streetcar operations in public streets.
- D. All OCS equipment is energized at a nominal 600 V DC, and shall be double insulated. A minimum of two levels of electrical insulation separated by a minimum distance of 4 feet shall be provided between the contact wire and a line pole or other grounded structure.
- E. Installation of OCS material shall be part of the coordinated work plan for the complete project. The Contractor shall be required to submit Procedures and Plans for all stages of work for Approval by the Engineer. Approval shall not relieve the Contractor from liability for damages incurred during installation of the OCS.

1.2 RELATED SECTIONS

- A. DIVISION 01 – General
- B. SECTION 26 – Traction Power Requirements
- C. SECTION 34 23 10 – OCS Description and General Requirements
- D. SECTION 34 23 35.99 – OCS Pole Painting
- E. SECTION 34 23 37 – OCS Tubular Steel Poles
- F. SECTION 34 23 37.11 – OCS Pole Ornamentation
- G. SECTION 34 23 40 – OCS Wire and Cable
- H. SECTION 34 23 50 – OCS Assemblies, Components and Fittings
- I. SECTION 34 23 77 – OCS Surge Arrester Installation
- J. SECTION 34 23 78 – OCS Disconnect Switch Installation
- K. SECTION 34 23 80 – OCS Testing

1.3 SUBMITTALS

- A. Submittals shall be made in accordance with the requirements of SECTION 01 33 00 of the Contract Documents, except as modified herein.

B. OCS installation procedures:

1. Submit procedures for all stages of OCS installation, including pole installation, cantilever framing and installation, headspan installation, bridle and pulloff installation, conductor stringing (including pre-tensioning and final tensioning methods), insulation cut-in, disconnect switch installation, and any other OCS installation activities. Procedures shall be Approved by the Engineer prior to commencement of the Work.
2. Submit staging plans providing the sequence of the Work, including methods of securing the Work during periods of interruption. Staging plans shall be Approved by the Engineer prior to commencement of the Work.
3. Submit manufacturers data and usage procedures for tools used to grip contact wire during stringing and where held under tension. The Contractor shall use a grip method that does not produce a kink in the Contact Wire. Contact Wire kinks will not be accepted, without exception. The method of gripping shall be submitted to the Engineer for Approval, however Approval will not release the Contractor from liability if the method produces kinks in the Contact Wire.
4. Submit a schedule of OCS fabrication and installation activities to the Engineer on a weekly basis. Deviation from the schedule shall be reported to the Engineer on a daily basis.
5. Submit the updated conductor erection spreadsheet within five (5) days of the installation of each conductor length. Information on the spreadsheet shall include wire run number, length, pre-tension load, pre-tension temperature, duration of pre-tensioning, final tension load, final tension temperature, and notes describing any unusual circumstances.
6. Submit a schedule of pole stationing labels showing pole identification (ID) numbers, and warning signs for pre-approval before proceeding with their procurement or installation.

1.4 QUALITY ASSURANCE/QUALITY CONTROL

- A. Quality Control/Quality Assurance shall be in accordance with SECTION 01 43 00 except where modified within this specification section.

1.5 SAFETY REQUIREMENTS

- A. The health and safety of workers and the public shall be in accordance with applicable state and federal regulations, in conjunction with the project Specifications.

1.6 HANDLING

- A. OCS assembly, component, and fittings materials shall be packaged, handled, and transported to site in a manner that will prevent damage occurring to the material and any surface coatings.
- B. OCS Material shall not be stored in contact with the ground. It shall be stored in a manner and location that will not cause deterioration of the material.
- C. Materials delivered to site shall only be stockpiled in areas specified in the Construction Plan and Approved by the Engineer.
- D. Any damage to the materials and equipment shall be the Contractor's responsibility and all repairs shall be accomplished by the Contractor in accordance with the manufacturer's instructions, at the Contractor's expense.

1.7 LICENSING AND CERTIFICATION REQUIREMENTS

- A. All Work specified in this Section shall be performed by workers skilled and experienced in the installation of OCS systems.

B. Superintendent Qualifications

1. The OCS superintendent shall demonstrate previous superintendent experience in successfully performing Work of this type on a project of similar size and complexity. Experience shall include the supervision and training of OCS installation crew, as well as interpretation of OCS specifications, design drawings, OCS equipment manuals, and OCS manufacturer's design drawings.

C. OCS Installation Crew Foreman Qualifications

1. A foreman shall be appointed for each crew not exceeding six OCS installers, or where crews work independently. The foreman shall have demonstrated experience or training in the installation of OCS, and demonstrated experience as foreman of OCS installations or similar overhead line work.

D. OCS Installer Qualifications

1. OCS installers shall be qualified by experience and training to perform the specified work. A Journeyman Lineman shall have completed a federally approved Outside Line Construction and Maintenance apprenticeship program.

1.8 TOOLS

- A. Contact wire shall only be strung or held in tension by specifically designed grips that pull along the wire centerline without bending or kinking the wire.
- B. Tools that are deformed or otherwise damaged shall be discarded and replaced at the Contractor's expense.
- C. Fittings and equipment designed for permanent installation shall not be used as multiple use construction tools.

PART 2 - PRODUCTS

2.1 OCS SHOP DRAWINGS

- A. Shop drawings shall be submitted in accordance with SECTION 01 33 00 and all related OCS Specifications.
- B. Shop drawings shall be prepared by the contractor to perform the form, fit and function of each assembly reference given in the Contract Drawings, and be assigned the same assembly reference and assembly description.
- C. Shop drawings shall assign the full technical description of any pipe, wire or cable used in the detailed assembly.
- D. Shop drawings shall show the maximum rated strength and corresponding factor of safety of each assembly as appropriate.
- E. Shop drawings shall be specifically designed for use on this project and submitted for approval and approved by the Engineer.
- F. Each shop drawing shall be supported by component drawings and/or catalog cuts as appropriate.
- G. Shop drawings shall be supported by appropriate index sheets of both assembly references and of components numbers.

2.2 CONTACT WIRE

- A. Contact wire shall be supplied in accordance with SECTION 34 23 40 – OCS Wire and Cable.

2.3 JUMPERS

- A. Insulated and bare jumpers shall be fitted with flexible jumper wire in accordance with SECTION 34 23 40, OCS Wire and Cable, and configured as shown in OCS Contract Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. The following describes the Work required for the installation of the assemblies, wiring, and fittings of the complete OCS system onto poles erected as specified in SECTION 34 23 72 – OCS Tubular Pole Installation.
- B. The Work shall also include design verification, stringing, tensioning, supporting, registering, and anchoring the conductors, installing jumpers, section insulators, disconnect switches, surge arresters, and other ancillary equipment and hardware, including contact wire bridges and other components, as required, to provide a complete and fully operational OCS.
- C. The Contractor shall be responsible for coordinating the OCS installation with other project civil, structural, systems, and electrical work.
- D. The Contractor shall submit, for review and approval by the Engineer, drawings for all temporary anchorages, guying, and electrical isolations.
- E. Fasteners shall include bolts, nuts, locknuts, washers, pins, turnbuckles, machine screws and other items that may be used to attach items together. Fasteners shall be installed in accordance with the manufacturer's recommendations. Bolts shall be of sufficient length to allow two full threads to extend beyond the nuts and locknuts; however, the end of the bolt must never extend more than 1.5 inches beyond the nut or locknut. Threads of all bolts, nuts and machine screws shall be lightly lubricated prior to assembly, and shall be torqued using a calibrated torque wrench in accordance with the manufacturer recommendations. Fittings, fasteners, or any other attachments that do not fit, are cracked, have sustained galvanizing damage during installation, or are found to be defective in any way, shall be rejected and replaced at the Contractor's expense.
- F. Drilling, cutting, or reaming of components will not be permitted without prior Approval of the Engineer.
- G. Turnbuckles, where used, shall be installed in a manner that will provide 50% of the available take-up and release, to remain for future adjustment.
- H. At all stages of work, Contact Wire is to be handled with special care to prevent bending, kinking, twisting or other forms of damage. Wire grips and other installation equipment shall be designed and used so as not to damage or bend the wire. Kinks in the Contact Wire will not be accepted under any circumstances.

3.2 INSTALLATION TOLERANCES

- A. The installed OCS shall conform to the dimensional requirements shown on the Contract Drawings and shop drawings, within the following tolerances:
 - 1. Pole rake at pole top (after loading at 60 degrees Fahrenheit) 1 inch off vertical
 - 2. Contact wire height:

a. At support	1 inch
b. At a bridge	0.5 inch
3. Contact wire stagger at registration	1 inch
4. Wire tension	50 lb

3.3 OCS ASSEMBLIES

- A. OCS support and termination assemblies, and all other defined and described OCS assemblies shall be constructed in accordance with approved shop drawings to the dimensions shown in the Contract Drawings.
- B. All OCS dimensioning shall be to the centerline of the track rails in the plane of the rail surfaces or as shown in the Contract Drawings.
- C. Prior to conductor stringing all installed supports and termination assemblies shall be restrained against movement by the wind and weather. In particular, cantilevers shall not be allowed to swing in the wind. Any materials damaged by inclement weather shall be discarded and replaced at the Contractor's expense.

3.4 CONTACT WIRE STRINGING

- A. Contact wire shall be installed in accordance with the Contractor's procedure, as approved by the Engineer. Allowance shall be made for conductor creep.
- B. In order to reduce creep, the Contractor shall pre-stress the contact wires while in temporary rollers or travelers for a minimum period of 48 hours prior to any clamping or clipping in at supports.
- C. Contractor shall submit the pre-stressing procedure to the Engineer for Approval, prior to commencement of stringing. The procedure shall describe the proposed method including:
 - 1. The pre-stress tension and pre-stress time period to be applied to the contact wire before being reduced to normal tension and adjusted to its final position, and clipped in
 - 2. The Contractor's check of the adequacy of the OCS structures and supports to ensure that they can safely carry any proposed loading in excess of the design values
- D. During final stringing, actual conductor temperature, as measured by contact thermometers, shall be used in conjunction with the conductor erection tables provided in the Contract documents to ascertain the various stringing parameters. The actual erection tension shall be based on conductor temperature and equivalent span. The climatic and span data shall be entered on a conductor erection spreadsheet developed by the Contractor, and shall be used to ensure conformity to the actual wire data before contact wire stringing is started. The conductor erection spreadsheet developed by the Contractor shall be updated and submitted to the Engineer within 5 days of the installation of each contact wire.
- E. The contact wire shall be attached to the anchor and strung out, being held in its approximate lateral position in relation to the track centerline by the use of temporary rollers at supports to prevent kinking. Rollers used by the Contractor shall not create kinks in the Contact Wire. The contact wire shall be strung under a tension adequate to keep the contact wire from touching the ground during stringing. After stringing, the contact wire shall be pre-stressed as described above before it is reduced to the contact wire tension for the ambient temperature, and the steady arms or other registrations attached, removing any twists in the contact wire by working from one anchor to the other. Wire pull-offs shall then be installed and tensioned.
- F. After final tensioning has been completed, cross-spans, cantilevers, and pull-offs shall be set normal to the track, and the contact wire heights and staggers adjusted as required to obtain the values given in the wiring layout drawings and wire schedule drawings.

3.5 CONDUCTOR SPLICES

- A. Splices shall not be installed in the in-running contact wires, without exception. At locations where the Contact Wire is out of running, splices may only be used with approval from the Engineer. Splices shall be positioned so as not to interfere with the operation of other wires, fittings or equipment under all climatic and operating conditions.

3.6 JUMPERS

- A. Continuity jumpers and feeder jumpers shall be erected where shown on the OCS layout drawings and shall be installed in accordance with the manufacturer's recommendations. The Contractor shall determine the lengths of the jumpers, based on actual field measurements, and the jumpers shall be installed, secured and shaped to avoid conflicts with the uplifted pantographs and so as to not restrict minor movement of adjacent cantilevers. Jumper wire shall have cut and tied ends that shall not project more than 1 inch through the connection clamps.
- B. Connection clamps shall be installed as in accordance with manufacturer's recommendations. Before fitting the connector clamps, the conductors shall be cleaned and wire-brushed to ensure a good electrical connection beneath the clamp, and shall be lubricated with a conductive grease as recommended by the manufacturer. The connector bolts shall be torqued to the manufacturer's recommendations using a calibrated torque wrench.
- C. Feeder cables shall be double clamped.
- D. Feeder jumpers shall be connected to the cantilever pipes and cross-spans by means of insulated clamps or clips

3.7 CONTACT WIRE BRIDGES

- A. Contact wire bridges shall be used for crossing of contact wires in crossovers and other areas where in running contact wires cross each other as shown on the layout drawings.
- B. Contact wire bridges shall be double clamped at each end.
- C. Contact wire bridges shall be installed at crossed contact wire locations shown on the layout drawings.
- D. The contact wire bridges shall allow some free movement of the contact wires over the operating temperature range. A minimum contact wire bridge length of 2 feet shall be used. The upper contact wire shall be adjusted to float through the contact bridge assembly under normal conditions with no pantograph uplift.

3.8 SECTION INSULATORS

- A. Section insulators shall not be cut into a contact wire until the adjustments of Section 1.15 have been completed and the contact wire is ready for final tensioning.
- B. Section insulators shall be located as shown on the contract drawings and only installed after the Engineer has given his approval to each site-specific location in the field.
- C. Section insulators shall be installed in accordance with the manufacturer's recommendations.
- D. Each section insulator shall be installed and adjusted to provide a smooth passage for the pantograph without causing rocking or arcing. The section insulator shall be free to move without twisting or becoming misaligned.
- E. Section insulators shall be installed in straight running contact wire, without deviation at the Section Insulator.
- F. All electrical connectors and clamps shall be prepared and protected externally and internally in accordance with the manufacturer's recommendations.

- G. Extreme care shall be taken during installation of section insulators and related components, to prevent the contact wire from being damaged. Any damage to the contact wire shall be repaired or replaced at the Contractor's expense.

3.9 SURGE ARRESTERS

- A. Install surge arresters per SECTION 34 23 77 – OCS Surge Arrester Installation, of these Specifications.

3.10 DISCONNECT SWITCHES

- A. Install disconnect switches per SECTION 34 23 78 – OCS Disconnect Switch Installation, of these Specifications.

3.11 BLUE LIGHT ASSEMBLY

- A. Blue light assemblies shall be installed as shown in the contract drawings. Orientation and location of the blue light shall be at a minimum 10 feet above TOR and visible to the operator sitting in street car operator's seat.

3.12 WARNING SIGNS AND POLE IDENTIFICATION NUMBERS

- A. Warning signs shall be installed at the following locations:
 - 1. Method of attachment of signs shall be Approved by the Engineer. At locations where method proves inadequate the Contractor shall design a different method of attachment for Approval. Any signs needing a new method of attachment will be replaced at the Contractor's expense.
 - 2. "Danger High Voltage" – On each pole in station platform areas and on each pole to which a switch operating handle is installed.
 - 3. The Contractor shall prepare a schedule of locations for warning signs for approval by the Engineer.
 - 4. Warning signs shall be installed on all poles at a height and orientation site specifically agreed by the Engineer.
 - 5. Pole I.D. numbers shall be installed on all OCS poles, with site specific exclusion being Approved by the Engineer.
 - 6. The Contractor shall prepare a schedule of locations for pole I.D. numbers for approval by the Engineer.
 - 7. Pole I.D. numbers shall be installed on all poles at a height and orientation site specifically agreed by the Engineer.

3.13 POLE GROUNDING

- A. Grounding and Bonding shall be performed in accordance with SECTION 26 05 06 – Grounding and Bonding, the Contract Drawings, and Specifications
- B. On each pole where a surge arrester is installed, a 2/0 insulated ground wire from the surge arrester shall be exothermically welded to the top of the lightning arrester ground rod. The surge arrester cable shall be a single piece of wire, with no splices or interruptions. If multiple lightning arresters are required, they shall each have their own ground rod and ground wire. OCS Contractor shall coordinate this work with all other Project Work.
- C. On each pole without a surge arrester, a 2/0 pole ground wire shall be exothermically welded to the top of the foundation ground rod. The final connection of the 2/0 ground wire shall be made with compression connectors bolted to a grounded stud or tag provided for that purpose inside the pole. OCS Contractor shall coordinate this work with all other Project Work.

- D. Where exothermic welds are to be made to a galvanized surface, galvanizing shall be removed using a grinding wheel to expose a clean surface. After welding, repair the galvanized coating on the steel surface using an Approved zinc rich cold galvanizing paint, ZRC Cold Galvanizing Compound, or an Approved equal. Surface preparation and application of the galvanizing repair shall be in accordance with the repair material manufacturer's recommendations.
- E. Exothermic welding cartridges and molds shall be for the type of weld shown on the Contract Drawings, and be performed in accordance with the manufacturer's recommendations. Worn and damaged molds shall be discarded and not used. Where directed by the Engineer, welds and molds shall be replaced.

3.14 REPAIRS

- A. Repairs to any part of the OCS shall only be made as approved by the Engineer. Damaged components shall be removed from site, or reported to the Engineer along with a proposed repair procedure. The Engineer shall determine if components shall be discarded and replaced at the Contractor's expense.
- B. Any insulator damaged or degraded in any way shall be replaced at the Contractor's expense, without exception.
- C. Vertical kinks in the contact wire shall be removed using a power operated tool or by hand using a leather or copper faced hammer to beat the contact wire against a flat smooth surface such as a hardwood block.
- D. Lateral kinks in the contact wire shall be removed if they affect the fit of any parts or are detrimental to pantograph operation. Twists in the contact wire shall be corrected.
- E. No contact wire kinks will be accepted in the final product, without exception.
- F. Damage to the galvanizing of poles, assemblies, components and hardware shall be repaired by the application of an Approved zinc-rich, cold galvanizing repair paint, ZRC Cold Galvanizing Compound, or an Approved equal. Surface preparation and application of the galvanizing repair shall be in accordance with the repair material manufacturer's recommendations.
- G. All Work associated with touch-up painting and grouting will be at the Contractor's expense.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 34 32 71 OCS POLE FOUNDATIONS

PART 1 - GENERAL

1.1 SUMMARY

- A. The Work covered by this Specification shall include the furnishing of all labor, equipment, tools, services and materials for complete and proper installation of Overhead Contact System (OCS) pole foundations as indicated on the plans.
- B. The work to be performed under this specification shall include all surveying and field layouts necessary for the correct location of the pier foundations.
- C. Provide and install steel reinforcement, anchoring and grounding devices within the foundations.
- D. Excavate the foundations, furnish all cast-in-place concrete foundations.
- E. Clean up the work areas after completion of each foundation.

1.2 RELATED SECTIONS:

- A. DIVISION 01
- B. SECTION 34 23 10 – OCS Description and General Requirements
- C. SECTION 26 05 26 – Grounding and Bonding
- D. SECTION 34 23 70 – OCS Installation
- E. SECTION 34 23 77 – OCS Surge Arrester Installation
- F. SECTION 34 23 78 – OCS Disconnect Switch Installation
- G. SECTION 34 23 80 – OCS Testing
- H. TEXAS DEPARTMENT OF TRANSPORTATION GOVERNING SPECIFICATIONS AND SPECIAL PROVISIONS, AS LISTED IN CITY OF EL PASO: STREETCAR PROJECT TECHNICAL SPECIFICATIONS

1.3 REFERENCES

- | | | | |
|----|------|---------|---|
| A. | ASTM | A36 | Structural Steel |
| B. | ASTM | A123 | Zinc Coating (Hot-Dip Galvanized) on Iron and Steel Products |
| C. | ASTM | A153 | Zinc Coating (Hot-Dip) on Iron and Steel Hardware |
| D. | ASTM | A252 | Welded and Seamless Steel Pipe |
| E. | ASTM | A615 | Deformed and Plain Billet-Steel Bars for Concrete Reinforcement |
| F. | ASTM | F1554 | Standard Specification for Anchor Bolts |
| G. | ACI | ACI-305 | Recommended Practice for Hot Weather Concreting |
| H. | ACI | ACI-306 | Recommended Practice for Cold Weather Concreting |

I.	AASTHO Iron	M-232	Specification for Zinc Coating (Hot-Dip Galvanized) on and Steel Hardware
J.	AASTHO	M-291	Specification for Carbon and Steel Nuts
K.	AASTHO	M-293	Specification for Hardened Steel Washer
L.	AASTHO	M-342	Specification for Steel Bolts and Studs
M.	AWS	D1.1	Structural Welding Code – Steel

1.4 SUBMITTAL

- A. Submit the following for approval in accordance with SECTION 01 33 00 under the General Requirements.
 - 1. Shop Drawings
 - 2. Certificates and Test Reports
 - 3. Written description of construction procedures, material used, Product Data and equipment for drilling the foundation

1.5 QUALITY ASSURANCE

- A. Contractor shall employ sufficient personnel skilled and experienced to properly perform the work of this section, and shall use adequate equipment.
- B. Contractor shall perform the following in accordance with the requirements of the Contractor's Quality Control Program as approved by the Engineer.
 - 1. Material qualification testing and mill certification for acceptance
 - 2. Job control testing of in-progress work in shops and continuous field inspection
- C. Installation of ground rods and other electrical material shall be by licensed Electricians, registered in the State of Texas.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Materials shall be delivered to the site in undamaged condition and stored off the ground in a well drained location, protected from damage, and easily accessible for inspection and handling.

1.7 PROJECT CONDITIONS

- A. Comply with ACI 305 and 306 during hot and cold weather conditions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS AND MATERIALS

- A. Temporary Casing Shell: Steel casing shall have an outside diameter equal to or greater than the specified diameter of the drilled shaft, and shall have sufficient strength to withstand handling stresses, concrete pressure, and surrounding earth or fluid pressures.
 - 1. Concrete:
 - a. As specified in TEXAS DEPARTMENT OF TRANSPORTATION GOVERNING SPECIFICATIONS AND SPECIAL PROVISIONS, AS LISTED IN CITY OF EL PASO: STREETCAR PROJECT TECHNICAL SPECIFICATIONS except as modified herein.
 - b. Concrete shall have a minimum compressive strength of 3600 psi at twenty-eight days.

B. Reinforcement:

1. As specified in TEXAS DEPARTMENT OF TRANSPORTATION GOVERNING SPECIFICATIONS AND SPECIAL PROVISIONS, AS LISTED IN CITY OF EL PASO: STREETCAR PROJECT TECHNICAL SPECIFICATIONS except as modified herein.

C. Anchor Bolts:

1. As specified in TEXAS DEPARTMENT OF TRANSPORTATION GOVERNING SPECIFICATIONS AND SPECIAL PROVISIONS, AS LISTED IN CITY OF EL PASO: STREETCAR PROJECT TECHNICAL SPECIFICATIONS except as modified herein.

D. Concrete Formwork:

1. Refer to TEXAS DEPARTMENT OF TRANSPORTATION GOVERNING SPECIFICATIONS AND SPECIAL PROVISIONS, AS LISTED IN CITY OF EL PASO: STREETCAR PROJECT TECHNICAL SPECIFICATIONS and as specified below.
2. Forms used in constructing pier above ground level shall be of sufficient strength to withstand the pressure of concrete and shall provide concrete having smooth surface.

E. OCS Pole Grounding

1. OCS Foundations shall include pole grounding installation as shown in the Contract Drawings and described in the Specifications.
2. OCS foundations at locations with surge arresters shall include surge arrester grounding installation as shown in the Contract Drawings and described in the Specifications.
3. Grounding rods shall be in accordance with SECTION 26 05 26 – Grounding and Bonding.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Walkout Survey: After the Contractor has established the location of pole foundations, and prior to starting excavation, a walkout survey shall be conducted by representatives of Engineer and the Contractor, and any other parties affected by foundation locations, in order to resolve any problems resulting from pole placement in the indicated location.

3.2 EXCAVATION/ERECTION/APPLICATION

- A. Drill the pier shafts at locations and to the dimensions and depths as indicated on the plans and control them within the specified tolerances.
- B. Abandoned pipe, concrete, boulders and other obstructions, which extend into the pier shafts and prevent the proper formation of piers shall be removed. The permanent utility lines and piping which are interfered with by the pier shafts shall be brought to the Engineer's attention.
- C. Blasting shall not be permitted for use on OCS pole foundations.
- D. Excavated drilling materials that are surplus, or do not comply with the reusable materials as specified, shall be removed from job-site and disposed of as directed.
- E. Steel casing shells shall be used, where required by the Engineer to control ingress of water or prevent caving of the pier shaft.
- F. Reinforcing steel, anchor bolts shall be installed as follows:
1. Place the reinforcement and install the anchor bolts, and grounding plates or rods in the foundations. Reinforcement shall not be spliced.

2. The reinforcing cage shall be placed symmetrically about the axis of foundations, and shall be securely braced to maintain the minimum clearance of concrete cover as indicated. Maintain in clean condition until embedded in concrete.
 3. The anchor bolt assemblies, grounding plates and rods shall be located and oriented as indicated, with the specified tolerances.
 4. Prefabricated templates shall be used to hold the projecting portion of the anchor bolts in their proper positions.
- G. Remove all loose material from the bottom of the drilled shafts and dewater as required prior to and during placing of concrete.
 - H. Immediately after approval of the reinforcement and anchor bolts installation by the Engineer begin the placement of the concrete. Concrete shall be placed in one continuous operation in each pier shaft.
 - I. To prevent segregation of concrete, place concrete by tube or tremie method.
 - J. Excavation, installation of reinforcement and anchor bolts, and concreting of the foundation shall be scheduled so that each drilled shaft is poured within twelve hours after excavation. The number of foundations left open at the end of a work day shall be kept to a minimum and shall be adequately covered and protected against possible hazards.
 - K. Wherever steel casing shells are used, they shall be withdrawn as the concrete is placed. An adequate head of concrete shall be maintained above the bottom of the casing to resist the soil and water pressures.
 - L. The anchor bolt template may be removed from a pier and reused elsewhere two days after the concrete has been placed.
 - M. All exposed, rough concrete surface shall be steel troweled to produce a smooth, dense surface. Pier top shall be finished with 1% slope, as indicated on the Contract plans.
 - N. OCS pole and surge arrester grounds shall be tested in accordance with SECTION 34 23 80 – OCS Testing.
 - O. Conduit sleeves for feeder cables, lighting cables, lightning arrester cables, traffic signals, and any other amenities shall be verified and installed prior to pouring foundation concrete.

3.3 FIELD QUALITY CONTROL

- A. Allowable Tolerances:
 1. Allowable OCS foundation construction tolerances shall be in accordance with TEXAS DEPARTMENT OF TRANSPORTATION GOVERNING SPECIFICATIONS AND SPECIAL PROVISIONS, AS LISTED IN CITY OF EL PASO: STREETCAR PROJECT TECHNICAL SPECIFICATIONS, except as modified herein.
 2. Each pier foundation shall be located within 2 inches of its offset dimension, as indicated on the foundation plans or as approved by the Engineer.
 3. To avoid local obstructions the along-track positions of pier foundation indicated may be modified by up to ± 5 feet. Adjacent to special trackwork or curved track of a 500 foot radius or less, the along-track positions of the OCS pole foundation can only be modified by up to
 4. ± 2 feet. Such modifications are subject to prior approval by the Engineer.
 5. Axis of the shaft shall not be out of plumb more than 1% of its excavated depth.
 6. Each pier foundation shall not be less than the correct diameter and length indicated on the plans.

7. Each anchor bolt shall be located within 1/8 inch of its correct horizontal position and 1/2 degree of true vertical in its anchor bolt assembly, as indicated on the plans.
8. Anchor bolt assembly shall be located within 1-1/2 inches of its correct offset dimension and vertical position, as indicated in the plans. The anchor bolt positions shall be determined relative to the offset dimensions from the vertical and horizontal base lines, or track center line.
9. Each anchor bolt assembly shall be located within two degrees of its correct orientation, as indicated on the plans.
10. The top of concrete of each foundation shall be within 1/4 inch of its correct elevation, as indicated on the plans.

3.4 ADJUSTING AND CLEANING

- A. Notify the Engineer after installation of the reinforcement, anchor bolt assembly in each foundation that the installation is ready for inspection. Adjust the reinforcement, anchor bolts as required by the Engineer.
- B. At the conclusion of the foundation work, remove equipment used in the work, and remove all debris, surplus material, and excavated soil from the premises.

3.5 PROTECTION

- A. Open pier shafts and incomplete construction shall be covered to prevent hazards.
- B. Protect projecting and exposed surfaces from injury during entire construction period.
- C. The anchor bolts shall be protected from damage and prevented from moving during placement and curing of the concrete.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 34 23 72 OCS TUBULAR POLE INSTALLATION

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section covers the delivery to site and installation of new tapered tubular steel poles and accessory parts, for use as part of the Overhead Contact System (OCS) as shown on the Contract Drawings.

1.2 RELATED SECTIONS

- A. SECTION 01 33 00 – Submittal Requirements
- B. SECTION 01 43 00 – Systems Quality Assurance
- C. SECTION 26 05 26 – Grounding and Bonding
- D. SECTION 34 23 10 – OCS Description and General Requirements
- E. SECTION 34 23 35.99 – OCS Pole Painting
- F. SECTION 34 23 37 – OCS Tubular Steel Poles
- G. SECTION 34 23 37.11 – OCS Pole Ornamentation
- H. SECTION 34 23 70 – OCS Installation
- I. Specifications for Street Lighting Attachments on OCS Poles shall be in accordance with Texas Department of Transportation Governing Specifications and Special Provisions, in conjunction with Approval from the Engineer.
- J. Specifications for Traffic Signal Attachments on OCS Poles shall be in accordance with Texas Department of Transportation Governing Specifications and Special Provisions, in conjunction with Approval from the Engineer.

1.3 REFERENCE STANDARDS

- A. The latest edition of the following reference specifications shall also govern the Work covered by this Section unless otherwise noted.
 - 1. MILSPEC DOD-P-21035 Paint, High Zinc Dust Content Galvanizing Repair

1.4 SUBMITTAL

- A. Submittals shall be made in accordance with the requirements of SECTION 01 33 00, except as modified herein.
 - 1. The Contractor shall make calculations for each pole.
 - 2. The Contractor shall submit pole installation procedures.

1.5 QUALITY CONTROL/QUALITY ASSURANCE

- A. Quality control shall be in accordance with SECTION 01 43 00, except where varied herein.

1.6 HANDLING AND STAGING

- A. Any damage to the material and equipment shall be the Contractor's responsibility and all repairs shall be accomplished by the Contractor in accordance with the manufacturer's instructions, at the Contractor's expense.
- B. Pole staging areas shall be coordinated and approved with the Engineer prior to installation.
- C. Material shall not be stored in contact with the ground. It shall be stored in a manner and location that will not cause deterioration of the material.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

3.1 PREPARATION

- A. Initially verify the suitability of installation of the pole on the foundation by applying a template to the pole base.
- B. Perform any preparatory work necessary to install the pole such as chipping off concrete on anchor bolts and cleaning threads.
- C. Straightening of bent anchor bolts or replacement of damaged ones shall be performed in accordance with a procedure approved by the Engineer.

3.2 ERECTION/INSTALLATION

- A. Poles shall not be installed on foundations until 14 days after concrete pour and concrete strength as measured by test cylinders has achieved at least 90% of the minimum compressive strength specified.
- B. Poles shall be installed on the foundations where shown on the Contract Drawings as approved by the Engineer. The Contractor shall remove the protection cap PVC protection sleeves and cap from anchor bolts, prior to setting the pole.
 - 1. Rake poles to provide a vertical pole, with tolerance not to exceed 1 inch, when loaded.
- C. Grounding and Bonding: All steel poles installed by the contractor shall be bonded to the foundation grounding rod, using the grounding studs or lugs, and attached to the pole as shown on the OCS Contract Drawings. For tubular poles, grounding and bonding equipment may need to be installed prior to pole erection.
- D. Poles shall be set with handhole oriented in the direction facing away from traffic and with the Pole Type Identification Number facing tracks or curbs. Poles between two tracks shall be set with the handhole oriented in the down-station direction.
- E. Pole fittings: The contractor shall install all bolted and clamped fittings required for specific installation including, but not limited to, the following items:
 - 1. Feeder Spouts.
 - 2. Accessories required for Ornamental Poles
 - 3. Accessories required for Lighting Pole attachments

4. Accessories required for Traffic Pole Accessories
 5. Pole Caps
- F. Feeder poles:
1. Feeder poles shall be fitted with a cable support ("J") Hook and terminating bushings at the cable entrance hubs. The terminating bushings will be weatherproof, of compression seal type. The pull wire at the top of the pole shall be terminated with 2 (two) feet of free end length.
 2. Feeder poles shall be installed with the spouts parallel to track.
- G. Ornamental poles:
1. Poles designated in the Contract Drawings as Ornamental Poles shall have removable, two-piece clamshell style pole base covers that enclose the pole baseplate.
 2. Refer to SECTION 34 23 37.11 – OCS Pole Ornamentation and the Contract Drawings for Ornamental pole requirements.
- H. OCS poles with Street Lighting Attachments:
1. Contractor shall coordinate required assembly installation for poles designated with street lighting attachments in the Contract Drawings with entire Project Work. Installation of street lighting accessories shall be in accordance with Contract drawings and Specifications, or as otherwise directed by the Engineer.
 2. Refer to Texas Department of Transportation Governing Specifications and Special Provisions and the Contract Drawings for street lighting attachment requirements.
- I. OCS poles with Traffic Attachments:
1. Contractor shall coordinate required assembly installation for poles designated with traffic attachments in the Contract Drawings with entire Project Work. Installation of traffic accessories shall be in accordance with Contract Drawings and Specifications, or as otherwise directed by the Engineer.
 2. Refer to Texas Department of Transportation Governing Specifications and Special Provisions and the Contract Drawings for traffic attachment requirements.
- J. After complete installation of the pole the following information shall be recorded by the Contractor and submitted to the Engineer in the as-built drawings:
1. Pole stationing and referenced track
 2. Pole size
 3. Pole length
 4. Face of pole to track centerline dimension
 5. Pole Rake
 6. Details and dimensions of any Accessories installed on the pole
- K. Signs and Markers shall be installed as specified in accordance with SECTION 34 23 70 – OCS Installation.

3.3 REPAIR COATINGS

- A. Completed pole assemblies shall be hot-dip galvanized in accordance with ASTM A123, and painted in accordance with SECTION 34 23 35.99 – OCS Pole Painting.
- B. Field repair of zinc coated surfaces or painted surfaces shall be in accordance with SECTION 34 23 35.99 OCS Pole Painting.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 34 23 77 OCS SURGE ARRESTER INSTALLATION

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section covers the installation of surge arresters for the Overhead Contact System (OCS), as shown on the Contract Drawings, and specified herein.
- B. The Contractor shall provide and install surge arrester assemblies as shown in the Contract Drawings, including:
 - 1. All OCS poles serving as positive feeder cable risers
 - 2. Selected OCS poles as shown in the Contract Drawings
- C. The Contractor shall design, supply and install the necessary attachments for supporting the surge arrester at the top of the pole as shown in the Contract Drawings. The Contractor's designs and technical data for these assemblies shall be formally submitted and subject to Approval by the Engineer.

1.2 RELATED SECTIONS

- A. The Contractor shall familiarize himself with the contents of the following Divisions/Sections of these Specifications:
 - 1. DIVISION 01 – General Requirements
 - 2. SECTION 01 33 00 – Submittal Procedures
 - 3. SECTION 01 43 00 – Systems Quality Assurance
 - 4. SECTION 26 – Traction Power Specifications
 - 5. SECTION 26 05 26 – Grounding and Bonding
 - 6. SECTION 34 23 40 – OCS Wire and Cable
 - 7. SECTION 34 23 50 – OCS Assemblies, Components, and Fittings
 - 8. SECTION 34 23 70 – OCS Installation
 - 9. SECTION 34 23 80 – OCS Testing

1.3 TYPES OF SURGE ARRESTERS

- A. One type of surge arrester shall be procured in accordance with SECTION 34 23 50 – OCS Assemblies, Components, and Fittings. Surge Arrester assemblies shall include all accessories required to attach the Surge Arrester to the OCS Pole, as well as the required length of cable to connect to the ground rod.

1.4 SUBMITTALS

- A. Submittals shall be made in accordance with the requirements of SECTION 01 33 00 – Submittal Procedures, except as modified herein.
- B. The following submittals shall be made:
 - 1. Complete manufacturer's descriptions, catalog data, electrical ratings, test performance reports and product/assembly information including model number
 - 2. Manufacturer's general detail and arrangement drawings, and installation instructions, including manufacturer's maximum recommended grounding resistance
 - 3. Schematic wiring and interconnection diagrams
 - 4. Operation and maintenance manual, with list of spare parts
 - 5. Manufacturer/supplier recommended field testing procedures to confirm arrester serviceability, including resistance testing with a hand held Volt/Ohm meter
 - 6. Test Procedures and Reports in accordance with SECTION 34 23 80 – OCS Testing.

PART 2 - PRODUCTS

2.1 SURGE ARRESTER

- A. Surge arrester assemblies shall be in accordance with SECTION 34 23 50 – OCS Assemblies, Components, and Fittings, in conjunction with these Specifications.
- B. Each surge arrester shall be suitable for OCS pole mounting, and supplied with all accessories required for mounting. The surge arrester assembly shall incorporate an individual grounding system which shall be connected to a ground rod or ground mat as shown in the Contract Drawings.
- C. Each grounding connection shall achieve a grounding resistance of 5 Ohms or less, or as specified by the surge arrester manufacturer for the type of unit supplied, if the recommended resistance is less than 5 Ohms.
- D. Each individual surge arrester grounding connection and system shall be tested in accordance with the testing procedures specified in SECTION 34 23 80 – OCS Testing.
- E. Each surge arrester shall be bonded to the grounding system by a No. 2/0 AWG copper wire with 2000 V rated insulation, or with increased conductor and insulation ratings if so recommended by the arrester manufacturer.
- F. Bonding cable connections between the surge arresters and the OCS, and between the surge arresters and the grounding system shall be installed with a minimum number of bends and connections. Bends in the cables shall be no less than 8 inch radius.
- G. Surge arrester ground cable shall be uninterrupted between arrester and ground. No splices or other connections shall be permitted.
- H. Bonding connections between the surge arresters and the grounding systems shall be of the exothermic weld type.
- I. Refer to SECTION 26 05 26 GROUNDING AND BONDING for general requirements on grounding and bonding connections.

PART 3 - EXECUTION

3.1 INSTALLATION REQUIREMENTS

- A. Surge arresters shall be installed at locations shown on the Contract Drawings in accordance with the arrester manufacturer recommendations and as specified herein.
- B. Pole shall be field drilled with a hole to accommodate the lightning arrester ground cable and protective grommets. Field drilled hold shall be coated with touch-up paint in accordance with the Specifications and the pole manufacturer.
- C. Where grounding cables are attached to lightning arresters, sufficient slack shall be installed.
- D. Surge arrester ground wires shall be a single piece of wire, with no splices or interruptions. If multiple lightning arresters are required, they shall each have their own ground rod and ground wire.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 34 23 78 OCS DISCONNECT SWITCH INSTALLATION

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section covers installation of pole mounted DC disconnect switches on OCS poles and connection to the OCS conductors, as shown on the Contract Drawings and specified herein.
- B. The disconnect switch assembly is to be used as an in-line switch in the OCS. It provides a means to disconnect OCS line sections from one another to enable de-energization of one of them. Disconnect switch assemblies will not normally be operated under load conditions.

1.2 RELATED SECTIONS

- A. The Contractor/manufacturer shall familiarize himself with the contents of the following Divisions and Sections of the Contract Specifications:
 - 1. DIVISION 01 – General Requirements
 - 2. SECTION 01 33 00 – Submittal Procedures

1.3 DISCONNECT SWITCH ASSEMBLY TYPES

- A. Disconnect switches are procured under SECTION 34 23 50 – OCS Assemblies, Components and Fittings. For installation on poles to connect/disconnect two adjacent sections of OCS. Each disconnect switch shall be operated using a detachable insulated manual operating handle specifically designed for the purpose.

1.4 REFERENCE DRAWINGS

- A. The locations of poles on which to mount disconnect switch assemblies are shown on the Contract Drawings.

1.5 SUBMITTALS

- A. Submittals shall be made in accordance with the requirements of SECTION 01 33 00 SUBMITTAL PROCEDURES, except as modified herein.
- B. For each type of disconnect switch, the following submittals shall receive approval by the Engineer before installation in the OCS:
 - 1. Complete manufacturer's descriptions, shop drawings, catalog data, enclosure color, electrical performance ratings and information including model number.
 - 2. Manufacturer's general and detail arrangement and dimensional drawings (shop drawings)
 - 3. The shop drawing for each assembly shall be referenced with the assembly reference and shall represent in full the equivalent project assembly drawing.
 - 4. Each shop drawing shall provide a complete list of its component materials for that specific type of assembly, including the identification of materials to be supplied by others, such as pipes, brackets, bolts, cables, jumpers and cable connectors.

5. Manufacturer's recommended installation instructions, including checks/tests after installation
6. Operation and maintenance manual with list of recommended spare parts

PART 2 - PRODUCTS

2.1 GENERAL

- A. Each switch enclosure shall be mounted near the top of a taper tubular OCS pole or feeder pole equipped with feeder spouts, and provided with up to two surge arresters. The height and orientation of the disconnect switch enclosure shall be agreed by the Engineer.
- B. All exposed unit outdoor switches shall be capable of operation with a 1/4-inch thick covering of glazed ice on the external switch mechanism.
- C. Switch Enclosures
 1. Non-metallic fiberglass switch enclosures shall be of a ventilated, rain-tight, tamperproof design suitable for outdoor application. The enclosure shall have a gasketed, heavy duty hinged door with padlockable handle, catch, full length hinge (one sided) and hooded ventilation openings with screens.
 2. One specified outdoor type padlock shall be provided with each cabinet (enclosure), all keyed alike. A dead front operating handle and linkage shall be provided inside the box for each switch.
 3. The switch position shall be visually indicated by the handle alignment with "OPEN" and "CLOSED" plates.
 4. The enclosure shall be of sufficient size to accommodate the switch, internal linkages and operating gear, cabling and terminations without electrical shorting or damage due to chafing on the feeder cable insulation. All maintainable components shall be readily accessible through the door opening, and sufficient space shall be provided for the manipulation of required tools.
 5. The exterior face of the cabinet shall be equipped with a switch data/nameplate and a Danger - High Voltage warning label permanently attached to the cabinet.
 6. The enclosure shall be a minimum of 1/4-inch thick polyester, with a glass to resin ratio of 40 to 60 and shall be equipped with a drain hole in the base. Resin shall be fire retardant polyglass or equal as Approved by the Engineer. Enclosure color shall be subject to Approval of the Engineer.
- D. Padlocks
 1. Each pole mounted disconnect switch shall be provided with an outdoor type, heavy duty, keyed padlock (Master Lock APro-Series@ #6121), having a hasp diameter of 2-inch minimum.
 2. All padlocks shall be keyed alike. Two keys shall be provided for each padlock.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. The Contractor shall submit shop drawings for the disconnect switch support bracket for Approval by the Engineer before any switch is installed.
- B. Disconnect switches shall be field installed at OCS pole locations as shown on the Contract Drawings.
- C. Disconnect switches shall be installed in accordance with the manufacturer's instructions.
- D. The Contractor shall check the adequacy of poles for supporting the disconnect switches and accessories.
- E. All wiring shall be provided as required. All necessary additional hardware such as bolts and support brackets, couplings, bushings, connectors, grounding conductors, and all basic electrical materials needed for the installation of disconnect switch assemblies shall be supplied and installed by the OCS Contractor.
- F. Prior to energization of the OCS, the Contractor shall verify correct operation of all disconnect switches installed under this Contract, and shall demonstrate to the satisfaction of the Engineer the intended operation. Final switch positions shall be verified prior to OCS energizing without exception.
- G. The installation shall conform to the National Electrical Code (NEC).

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 34 23 80 OCS TESTING

PART 1 - GENERAL

1.1 SUMMARY

- A. The Traction Electrification System and all its components shall be tested to verify compliance with all specified design, performance, reliability, and maintainability requirements.
- B. All tests described in this Section shall be performed as indicated unless specifically waived in writing by the Engineer. All tests shall be performed on production components without modification or special preparation.
- C. The tests specified herein are considered to be an absolute minimum by the Engineer. The Contractor shall be responsible for assuring that each design and performance requirement of this Specification is assigned to a specific test effort. The Contractor shall furnish a comprehensive test plan as specified. The Contractor and its subcontractors may perform additional testing, as they deem necessary.
- D. Material test requirements may also appear in other Sections. Other test requirements may appear in other Sections. The Contractor shall integrate all of these tests into the Master Test Plan.
- E. After the Overhead Contact System (OCS) has been installed, and is to be made ready for operation, field acceptance testing shall be performed to verify physical and electrical integrity of the system, and to verify quality of workmanship.
- F. Following completion of all field acceptance testing, vehicle tests shall be performed to demonstrate clearances and commutation.
- G. This Section covers field-testing procedures, supply of test equipment and testing of the Overhead Contact System (OCS), visual inspections prior to energization, streetcar slow speed, commutation and pantograph clearance tests.

1.2 RELATED SECTIONS

- A. DIVISION 01 – General
- B. SECTION 26 – Traction Power Requirements
- C. SECTION 34 23 10 – OCS Description and General Requirements
- D. SECTION 34 23 37 OCS Tubular Steel Poles
- E. SECTION 34 23 40 – OCS Wire and Cable
- F. SECTION 34 23 50 – OCS Assemblies, Components and Fittings
- G. SECTION 34 23 70 – OCS Installation
- H. SECTION 34 23 71 OCS Pole Foundations
- I. SECTION 34 23 77 OCS Surge Arrester Installation
- J. SECTION 34 23 78 OCS Disconnect Switch Installation
- K. SECTION 34 23 90 OCS Installation Records

1.3 REFERENCED STANDARDS

- A. See Referenced Standards in SECTION 10 – OCS Description and General Requirements

1.4 SUBMITTALS

- A. Submittals will be in accordance with SECTION 01 33 00. Submit a Test Program Plan for approval within 60 days of the Notice to Proceed. The Test Plan shall be used as a controlling document for all tests and shall include test procedures and proposed test reports. The purpose of this plan is:
1. Ensure that the Contractor has considered all of the testing requirements contained in this and other Sections of the Specifications, and has made adequate provisions for testing in his overall program plans and schedules.
 2. Achieve an early mutual understanding between the Contractor and the Engineer on the range, depth and other aspects of tests to be conducted.
- B. The Test Program Plan shall contain as a minimum the following data:
1. Title of each test with reference to the respective article or Section number in the Specification
 2. The name of the agency performing each test, a description as the being Contractor, his supplier, or an independent testing company
 3. Test locations
 4. Submittal date for each test procedure, test report, and/or certified test document
 5. Scheduled starting date for each test
 6. Scheduled completion date for each test
 7. Test objectives
 8. Test criteria
 9. A list of test equipment to be available on site during OCS installation, including optical stagger gauge or laser equipment, insulated height stick, mechanical pantograph gauge suitable for use on embedded track, insulated tape measures, a 6ft hand level, and a pantograph profile with sway "ears"
 10. Personnel requirements
 11. Test input and expected output
 12. Data to be recorded and form of data
 13. Test evaluation procedures
 14. Nature of required reports
 15. A sample of each type of form proposed for use
 16. A list of individual contact wire heights and staggers for every contact wire support or registration points for each step of the OCS configuration, on a stage-by-stage, step by step work schedule
 17. A list of acceptance measurements to be recorded upon completion of the OCS construction
- C. Prior to each test, the Contractor shall submit verification that the OCS meets the specifications to the Engineer.

1.5 QUALITY ASSURANCE/QUALITY CONTROL

- A. Quality Control/Quality Assurance shall be in accordance with SECTION 01 43 00 except where modified within this Specification Section.

1.6 SAFETY REQUIREMENTS

- A. The health and safety of workers and the public shall be in accordance with all Federal, State, and Local regulations, as well as any requirements stipulated by the Owner or Engineer.

1.7 TEST PROCEDURES

- A. The Contractor shall develop detailed test procedures, which include test report format and forms for recording data for each test. The Contractor shall submit five copies of each test procedure. The test procedures shall include applicable procedures specified in, but not limited to, ANSI, IEEE, or NEMA standards. A set of test procedures shall be prepared for each assembly and component in this specification.
- B. Test procedures must be reviewed and approved by the Engineer prior to commencement of each test. Each test procedure shall contain a step-by-step procedure for performing the test and shall include but not be limited to the following:
 - 1. Title of test
 - 2. Test objective
 - 3. Test location and time
 - 4. Required equipment and instrumentation
 - 5. Test criteria including data evaluation procedures
 - 6. Test methodology including test setup, with circuit diagrams and test sequence
 - 7. Test data requirements including forms and format for recording data
 - 8. Testing agency or company

1.8 TEST REPORTS

- A. The results of each test shall be recorded on approved test report forms. Each report shall document the test results obtained and shall include the following information:
 - 1. Title of test
 - 2. Test objectives
 - 3. Summary and conclusions
 - 4. Location and date of test
 - 5. List of all test equipment used with calibration data
 - 6. Conditions of test, including temperature and humidity
 - 7. Raw test data
 - 8. Reduced test data including tables, curves, photographs and any additional test data required to support the test results
 - 9. Test results in a form which can easily be compared to the Specification requirements
 - 10. Descriptions of all equipment and material failures, the reasons for the failure

11. Descriptions of all modifications to the equipment or wiring performed using the testing, and the reasons for the modifications, and the names of individuals approving such modifications
12. Abbreviations and references
13. Signatures of test witnesses

1.9 WITNESSING OF TESTS

- A. The Engineer will, at his option, witness all tests. At least 21 days prior to each test, the Contractor shall notify the Engineer in writing of the date, time, and location the test will be performed. If the Engineer decides not to witness a test or tests, test reports shall nevertheless be submitted to the Engineer for approval.
- B. The Witnessing of tests shall not be considered as acceptance of test results or test reports.

1.10 PERFORMANCE OF TESTING

- A. Factory design or production testing of individual components may be performed by the component manufacturer at the plant of manufacture or at an approved testing facility.
- B. Field testing of the complete OCS installation shall be performed by the OCS installer under the direct supervision of the field service engineer representing the manufacturer of the OCS equipment and the Contractor.
- C. Field testing of insulated power cables rated 2 kV and higher shall be performed by a NETA certified technician working for an independent testing company under the direct supervision of the manufacturer of the substation equipment, and hired by the manufacturer of the substation equipment. The NETA technician shall have at least five years' experience in construction acceptance testing. The testing company shall be a NETA member and shall be approved by the Engineer. After approval by the Engineer, the testing company shall not be discharged or otherwise replaced without his written approval.

1.11 TEST CLASSIFICATIONS

- A. The required tests are categorized as follows:
 1. Factory design tests shall be conducted by or under the supervision of the equipment manufacturer to demonstrate compliance with specified design requirements. These tests shall be performed on production components, assemblies, subsystems, and substations, and shall be performed on the highest level of assembly that will allow demonstration of design compliance. Design tests are limited to the number of units needed to demonstrate design compliance, typically one or two.
 2. Factory production tests shall be conducted by or under the supervision of the equipment manufacturer and include all efforts necessary to demonstrate that the unit to be delivered operates within specified limits and is in compliance with design requirements. Production test requirements may vary from an inspection and functional demonstration for a simple component to a full system functional demonstration of an assembly. Production tests shall be performed at the OCS manufacturer's facility prior to shipment of the OCS equipment to the field. These tests are routinely performed at the ambient conditions unless a specific environmental or operating limit is necessary to demonstrate acceptable operation.
 3. Field acceptance tests shall demonstrate that each installed OCS segment is ready for vehicle testing functionally and revenue service cosmetically. Field tests include Measurement, Mechanical, Clearance, Electrical, and Energization tests.
 4. Vehicle tests shall demonstrate clearances to pantograph and vehicle body, and operation at maximum permissible speed without loss of contact or physical interference with a pantograph by the OCS.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. The Contractor shall supply all tools and equipment for performance of the tests.

PART 3 - EXECUTION

3.1 FACTORY DESIGN TESTS

- A. Component design tests shall be run on each component specified in this Section, and submitted to The Engineer for approval. If the manufacturer of the equipment has already performed design tests, the existing test reports may be submitted to the Engineer for approval. Existing test reports will not be required to meet the format requirements specified in this Section; however the content of the reports shall include all relevant information. In the event the components have not been design tested, the tests shall be run on the first production units and performed in accordance with these Specifications.

- B. OCS Insulators -

The following design tests shall be performed as described in ANSI C29.1 for one insulator of each type and rating supplied:

1. Power Frequency Withstand
2. Impulse Withstand
3. Thermal Capacity
4. Mechanical Strength
5. Resistance

- C. OCS Section Insulators

The following design tests shall be performed for one section isolator of each type supplied:

1. Resistance to ultraviolet radiation and electrical tracking of the insulating material
2. Mechanical Strength
3. Electrical Tests

D. OCS Disconnect and Interconnect Switches

The following design tests shall be performed as described in ANSI C37.34 for one OCS disconnect or interconnect switch of each type and rating supplied:

1. Insulation resistance and high potential tests
2. Temperature rise
3. Short time current
4. Interrupting current

E. Poles

1. The contractor shall demonstrate the deflection of each type of pole procured under this Contract to the engineer. The demonstration shall be in the form of a factory design test, performed in the place of the manufacturer. The testing shall be non-destructive and at a time and place agreed by the Engineer. The parameter to be demonstrated is the deflection at the top of the pole. The purpose of the test is to determine that the type of pole has deflection characteristics that match or are lower than predicted by theoretical considerations.
2. For each Pole Type to be tested, the maximum allowable moment that can be applied to the base of the pole shall be calculated based on the properties of the material specified and the dimensions shown on the drawings for that Pole Type. Calculation of the maximum allowable moment shall take into account the effects of local buckling, if appropriate. The magnitude of the load applied to the top of the pole to apply the maximum allowable moment to the base of the pole shall be calculated and the pole tested by application of this load in 1/3 increments. The deflection of the top of the pole shall be measured and recorded for each load increment. At release of the full test load, measure and record any permanent set (deflection past the neutral point) of the pole.
3. In the case of tapered tubular poles, the theoretical deflection for application of these load increments may be calculated in accordance with Deflection Equations for Tapered Tubular Cantilevered Beams of the "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals" by the American Association of State Highway and Transportation Officials or other approved methods. In the case of wide flange shape poles, the theoretical deflection may be calculated by accepted formulas derived for the particular loading condition or other approved methods. Contractor shall submit method of calculation of theoretical deflection with the proposed test procedure for approval by the Engineer.
4. The theoretical calculated deflections shall be compared with the values measured and the pole shall be determined to have passed the deflection test if none of the measured values are greater than the theoretical value plus 10%. Measured values less than the theoretical calculated values shall be considered as complying with these requirements. Permanent set of the pole shall not be greater than 5% of the deflection that occurred under the maximum load.

5. The Contractor shall submit to the Engineer, in writing a test procedure for approval, prior to testing of any poles. The test procedure shall include method of application of loads, recording devices, calibration of devices, method calculation of theoretical deflections and any information deemed pertinent by the Engineer. The test procedure shall comply with the following minimum requirements:
 - a. Test Arrangement - Poles will normally be placed in a horizontal position for testing although the vertical position is allowed. The pole shall be bolted to a rigid foundation that resists all translation and rotation about any axis. Provision shall be made to accurately measure the load applied to the pole, deflection at the top of the pole and to monitor the movement of the test foundation at the base of the pole to confirm its rigidity.
 - b. Test Equipment – The loads shall be applied at the top of the pole by a crane or other suitable pulling devices. Loads shall be measured by using calibrated scales or load cells located in the pulling lines. Loading and/or measurement through a system of blocks, tackles or pulleys shall not be allowed.
 - c. Dead Load Pick Up – The load required to compensate for the dead weight of the pole in its horizontal position shall be calculated and added to the test load increments.
 - d. Loading Procedure – The pole shall be loaded with the required Dead Load Pick Up load and reference established to measure deflection of the top of the pole from this point. The pole shall be loaded by 33, 66, and 100 percent of the load calculated to apply the maximum allowable moment at the base of the pole. Each load shall be applied in a steady uniform manner from the Dead Load Pick Up load to the value of the increment plus the Dead Load Pick Up value and held for 3 minutes. The deflection of the top of the pole shall be measured at the start and end of the hold period to confirm no creep is occurring. If creep is detected, continue hold until deflection readings stabilize. If creep is detected after 10 minutes of hold, the pole is considered to have failed the test. Confirm that the no movement has been detected in the test foundation at the base of the pole. If movement is detected, take necessary steps to eliminate the movement and retest the pole. After the deflection has been measured, decrease the load in a gradual uniform manner to zero.
 - e. Reapply the Dead Load Pick Up load and compare with previous reference point(s) and establish new reference point if required. Record permanent set, if any. Apply load to next increment value and repeat above procedure for each increment (plus Dead Load Pick Up) value.
 - f. Recorded values for deflections measured at each increment and permanent pole set, if any, shall be compared with the above requirements and the pole type shall be accepted as passed if the results are within the requirements listed.
6. If the requirements are not met, that particular individual pole shall be rejected for use on the project and another pole of the same Type tested. If the second pole of the same Type does not meet these requirements, that pole will be rejected for use on the project and two additional poles of that Type shall be tested as above. If both poles meet the above requirements, the Pole Type will be accepted for use on the Project. If either pole does not meet the requirements, all poles of the Type tested shall be tested by the above method for acceptance for use on the Project.
7. The cost of this testing, any required re-testing, and the issue of test reports shall be included in the bid price, and no additional compensation will be paid to the Contractor.

3.2 FACTORY PRODUCTION TESTS

- A. Component Factory Production tests shall be run on each component specified in this Section, and submitted to the Engineer for approval.

B. Fittings, Hardware, and Cantilever Tubes

The following production tests shall be performed in accordance with ASTM standards:

1. Chemical Analysis Tests on each lot.
2. Sample galvanizing tests upon completion of fabrication.
3. Visual and dimensional tests upon completion of fabrication.
4. Tests to determine thread fittings of units, washers to bolts.
5. A lot shall consist of all castings produced by one furnace melt.

C. Disconnect and Interconnect Switches

The following production tests shall be performed as described in ANSI C37.34 for each disconnect or interconnect switch of each type and rating supplied:

1. Insulation resistance and hi-potential test.
2. Mechanical operation of all components.

D. Galvanized Steel Wires and Wire Rope

1. All grades of stranded steel wires used as support wires, guys, and pull offs shall be tested in accordance with ASTM A475.

E. Stainless Steel Wire and Wire Rope

1. Stainless steel wire and wire rope used as support wires and pull-offs shall be tested in accordance with ASTM A 555, ASTM A 368 and ASTM A 492.
2. Test reports shall be submitted.

F. Section Insulators

The following tests shall be performed in accordance with the applicable ANSI/IEEE Standards:

1. Dry flashover tests
2. Wet flashover tests
3. Low frequency dry withstand test
4. Low frequency wet withstand test
5. Impulse withstand test
6. The Contractor shall provide data to show that the insulator material is resistant to ultra- violet radiation and electrical tracking.
7. The messenger insulators shall be proof tested in accordance with the applicable Section of the Specifications, and the contact wire unit shall be tension-proof tested to applicable contact wire maximum tension plus design factors of safety.
8. All test reports shall be provided.

G. Insulators

The following production tests shall be performed in accordance with ANSI C29.1.

1. Visual and Dimension Tests:

- a. The entire surface shall be smooth and free from defects.
- b. If adhesives are used, the insulator shall be inspected to see that the fillet of adhesive provides a complete seal between the coating and end fitting.
- c. The insulator shall be inspected to verify that both end fittings are in line after being assembled on the rod.
- d. The insulator shall be in accordance with the approved shop drawings and specifications.

2. Routine Flashover

- a. A sampling of not less than 5% of each type of insulator shall be subject to a flashover test in accordance with ANSI C29.1.

3. Proof Test

- a. All insulators shall be subject to a mechanical strength proof test. The insulators shall be tested at room temperature for 10 seconds to 120% of the designed tensile, compressive or bending load, failure shall constitute rejection.

H. Overhead Contact System Conductors

1. All conductors shall be subject to factory quality control tests as required in the applicable Standards. Tests shall be required on each reel of wire prior to shipment to site. A certified copy of the test report for each reel shall be submitted to the Engineer. A copy of the test report shall be packed with each reel.
2. The OCS contact wire shall be tested in accordance with ASTM Standard B47. In addition, the contact wire shall be subject to a twist test. The twist test shall be performed as specified for round wire, except that six twists shall be required. Contact wire not meeting the twist test shall be rejected.

I. Poles

1. Material Testing shall be in accordance with Reference Standards given in SECTION 34 23 37 OCS Tubular Steel Poles.
2. Weld Testing shall be in accordance with AWS Specifications, as per SECTION 34 23 37 OCS Tubular Steel Poles.
3. Impact Testing shall be in accordance Reference Standards given in SECTION 34 23 37 OCS Tubular Steel Poles.
4. Galvanizing Testing shall be in accordance Reference Standards given in SECTION 34 23 37 OCS Tubular Steel Poles.

J. All galvanized items shall be inspected for conformance with the requirements of the following ASTM specifications, as applicable:

1. Galvanizing Compliance: A123 or A153
2. Embrittlement: A143
3. Distortion: A384

K. Inspection

1. Provisions shall be made for inspection of the fabrication and testing by the Engineer or his authorized representative. Inspection by the Engineer at the point of manufacture shall not constitute acceptance of the Work as specified.

3.3 VERIFICATION PRIOR TO FIELD TESTS

- A. Prior to conducting the field tests, the Contractor shall verify that the OCS equipment is installed according to the specifications and is in operable condition.
- B. Verify the physical integrity and quality of workmanship of the system installation.
- C. Verify electrical clearances equal or exceed criteria.
- D. Verify clearance envelope for vehicles and pantograph are not infringed.
- E. Verify electrical integrity of the system.

3.4 MEASUREMENT TESTS

- A. Upon completion and acceptance by the Engineer of each segment of construction, the Contractor shall measure the contact wire height, stagger, and other required dimensions and record the readings on a Measurement Test Data Form, in the presence of the Engineer's representative.
- B. Tests shall be scheduled in advance with the Engineer.
- C. The Acceptance Measurement Data form provided shall be used to record test data. A typical blank Acceptance Measurement Data form for catenary equipment is shown in Table 3.1.
- D. Since the OCS is a single contact wire fixed terminated system, all references to the messenger wire, balance weights, along track movement and other non-occurring issues, shall be struck through.
- E. All columns on the test form will be completed using data from field measurements taken in the presence of the Engineer's representative, from existing records or from computed data as noted. Descriptions of the OCS Measurement Test Data form fields and the procedures used for the associated testing follow:
 1. Track – Designation shown on the Contract Drawing
 2. Wire Run Number – Designation shown on the Contract Drawings
 3. Drawing No. – Of the OCS Layout Schedule where structures are to be shown and labeled
 4. Names – Of the persons responsible for the measurement and their respective organizations
 5. Sheet No. – Number in the series of forms on which the wire run measurements are to be shown
 6. Equipment Style – The style of catenary being measured
 7. Conductor Temperature – Temperature (°F) of the conductors at the time of measurement. This measurement will be monitored by the use of a dial-type thermometer inserted into a hole bored lengthwise into a 10" length of contact wire. The thermometer contact wire assembly will be held under the same ambient conditions as those experienced by the installed OCS.
 8. Weather and Air Temperature – Conditions at the time of measurement; temperature will be measured on-site
 9. Date – Of the measurement

10. Station No. Identification – Support structure stationing as shown on the layout schedules
11. Structure Set out (Pole Face to Rail distance) – Measured distance from the pole to abutment face to track centerline, taken with tape measure
12. Foundation Height – Measured height from top of foundation to top of near rail, + above rail, below rail
13. Crosslevel (Superelevation) – Difference between the elevators of the two rails measured at the structure location
14. Stagger – Distance from the contact wire to the super-elevated centerline of the track measured at the support location. This measurement will be taken using a catenary position measurement device. Stagger shall be recorded as L (left) or R (right) when viewed in the direction of increasing stationing. Record stagger to nearest $\frac{1}{2}$ inch.
15. CW Height – Distance from the contact wire to a line defined by the top of both rails at the point of measurement (the inclined reference point)
16. System Height – height of messenger wire above the contact wire measured at the support. This value is computed from measurements of messenger wire and contact wire heights taken from track level
17. Midspan Offset – Same as “Stagger” above, except taken at midspan. Same sign convention applies
18. Midspan C.W. Height – Same as “CW. Height” above, except measured at midspan
19. Midspan Crosslevel – Same as “Crosslevel” above, except measured at midspan. Measurement will be taken using level and tape measure.
20. Sag – The computed average of “C.W. Height” for the previous and next structure minus Midspan C.W. Height between the structures
21. Gradient – Rate of change of contact wire height; computed as the difference between contact wire height at two adjacent supports divided by the distance between the supports
22. Span Length – Along track distance between the two OCS supports
23. Balance Weight Rise or Fall – Position of balance weight at ambient temperature relative to the computed 60°F position
24. Position of Balance Weight Stops – Position of upper and lower balance weight top relative to foundation upper surface, taken from design calculations
25. Mean Balance Weight Position at 60°F – Position of balance weight top relative to foundation upper surface; taken from design calculations
26. In-Running Contact Wire Height – height of in-running contact wire at overlaps and turnouts
27. Out-of-Running Contact Wire Height – height of out-of –running contact wire at overlaps and turnouts
28. Bridge Clearance Approximate Station – Approximate station location of bridge clearance measurement, as measured from the nearest catenary pole location
29. Bridge Face/Low/Mid- Designate whether the measurement is taken at a bridge face, the bridge midpoint, or at the estimated low point of the bridge lower surface
30. Bridge Vertical Track Clearance – Vertical distance between the underside of the bridge and the superelevated centerline of the track

- 31. Messenger Wire to Bridge Distance with 50 lbs. C.W.
- 32. Remarks – as necessary
- F. The Engineer will use the Acceptance Measurements to determine compliance with the designs and will inform the Contractor of necessary corrections to be performed.
- G. The Contractor shall execute corrections at no further cost to the Engineer, except for adjustments required by the Engineer which are changes beyond the requirements specified in the Contract Documents.
- H. After executions of corrections, the Contractor shall re-measure and record affected data and submit the results to the Engineer.
- I. The Work of this Section shall not be complete until corrections are complete and approved by the Engineer.
- J. Completed Acceptance Measurement Tables shall be submitted in accordance with SECTION 01 33 00.

3.5 MECHANICAL TESTS

- A. Upon completion of the OCS installation, the Contractor shall verify the physical integrity of the complete system.
- B. The Contractor shall check, by visual inspection from ground level, that all the OCS components are correctly installed:
 - 1. Catenary poles are vertical.
 - 2. Steady arms are correctly positioned.
 - 3. Feeder disconnect switch operating mechanisms operate freely and correctly and switch-blade position corresponds to handle position.
- C. Following Measurement Tests, the Contractor accompanied by the Engineer's representative, shall carry out the following checks at contact wire level, and remedy any unsatisfactorily conditions detected:
 - 1. Check fit and tightness of all components.
 - 2. Check that all split pins and locknuts are secure.
 - 3. Check that the contact wire is free of kinks, twists, nicks or damage.
 - 4. Check stranded wires are free of damage to strands.
 - 5. Check steady arm heel settings and fittings are correct.
 - 6. Check that jumpers are of the correct type, have adequate travel capability, are properly fitted, and are well formed to avoid fatigue failure.
 - 7. Check that the clearance of wires passing through a cantilever at the same potential is at least 3 inches under normal climatic conditions.
 - 8. Check for clearance and insulation between adjacent or crossing contact wires.
 - 9. Check installation for locations of possible interference with passage of pantographs, including spots where pantographs could tangle with wires or suspension assemblies.
- D. From the ground, the Contractor shall make the following checks:

1. Check that all disconnect operating handles operate correctly and name plates are correctly positioned.
2. Check that the disconnect switches operate easily and that the blades open and close smoothly without sticking.

3.6 CLEARANCE TESTING

A. Overhead Contact System

1. The Contractor shall measure clearances between the conductors, OCS equipment that will be energized, and any fixed structure such as an overhead bridge. Corrections for temperature shall be made, for fixed terminated catenary, and for uplift of the conductors. Clearances shall be equal to or exceed the values given earlier in these Specifications.
2. The purpose of these tests is to verify the mechanical and electrical clearances of the vehicle pantograph on the system. Any section found to have insufficient clearance shall be adjusted to provide the required clearance.

B. Pantograph Clearance Envelope

1. The Contractor shall perform pantograph clearance envelope inspections. The purpose of these inspections is to verify the mechanical and electrical clearances of the pantograph on the OCS. The inspections shall be conducted after all installations are complete. Any OCS assembly found to have insufficient clearance shall be adjusted to provide the required clearance.
2. Inspections shall be performed with a rail mounted height and stagger gauge having the profile of the appropriate pantograph clearance envelope. This gauge shall be used to verify the mechanical clearances between the pantograph and OCS components such as the heels of steady arms and drop brackets, and the electrical clearance between the pantograph and civil structures, such as overbridges. For this purpose the contact wire shall be uplifted before clearance measurements are taken. All measurements shall be recorded.

C. Vehicle Mechanical Clearances to OCS Supports (excluding Pantograph)

1. Vehicle Clearance Inspections shall be performed using a rail mounted sway gauge based upon the streetcar clearance diagram appropriate to the section of track being checked, and allowing for track curvature, superelevation and track tolerances. Equipment shall be clear of the sway gauge by a minimum of 3 inches.

3.7 INTEGRATION TESTS WITH A STREETCAR

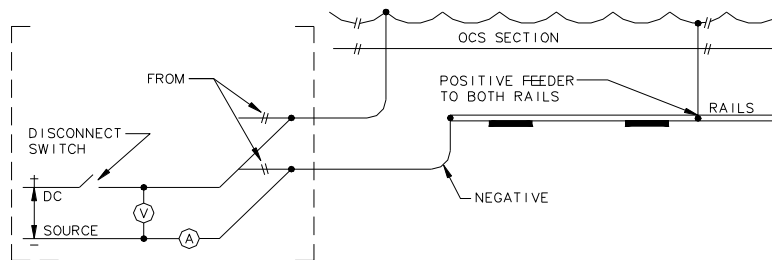
- A. Upon completion of the Measurement, Mechanical and Clearance Tests, the Contractor will initiate a low speed energized streetcar test run to confirm acceptable pantograph performance. A visual inspection of the pantograph interface to the wire will be performed. The test will demonstrate that the pantograph passing electrical clearances are adequate, no physical interference with pantograph movement, and sufficient pantograph security. During these tests, the Contractor shall have available plans, equipment and labor able to perform minor modifications to the OCS equipment.
- B. The Contractor shall conduct a survey of the overhead power distribution lines with a streetcar and equipment at normal operating speed. A video camera and recorder shall be used to record the pantograph head tracking on the OCS. The test shall verify that there is no contact loss between the vehicle pantograph head and the contact wire up to the maximum permissible speeds under normal operating conditions.

3.8 ELECTRICAL TESTS

A. Continuity Tests

1. With the OCS section de-energized the Contractor shall make a series of continuity tests to prove the continuity of each section of catenary and track in the area.
2. Each OCS section shall be formed by shorting the OCS to the track with jumpers at one end of the test section. Refer to Figure 3.1. The Contractor shall provide a 12 volt battery, a current measuring shunt, voltmeter, ammeter, and a switch to allow voltage and current measurements to be made.
3. The Contractor shall provide a 12 V battery, a current measuring shunt, voltmeter, ammeter, and a switch to allow voltage and current measurements to be made.
4. The Contractor shall record the results of the test and shall average the results of three loop resistance measurements using Table 3.3. A passing test shall constitute a nominal loop resistance not exceeding 0.1 ohm per mile of single track simple catenary style construction or 0.3 ohm per mile of single wire style construction. The cause of higher loop resistance values shall be investigated.

Figure 3.1



CONNECTION FOR THE DC LOOP RESISTANCE TEST
(CONTINUITY TEST)

B. Dielectric Test

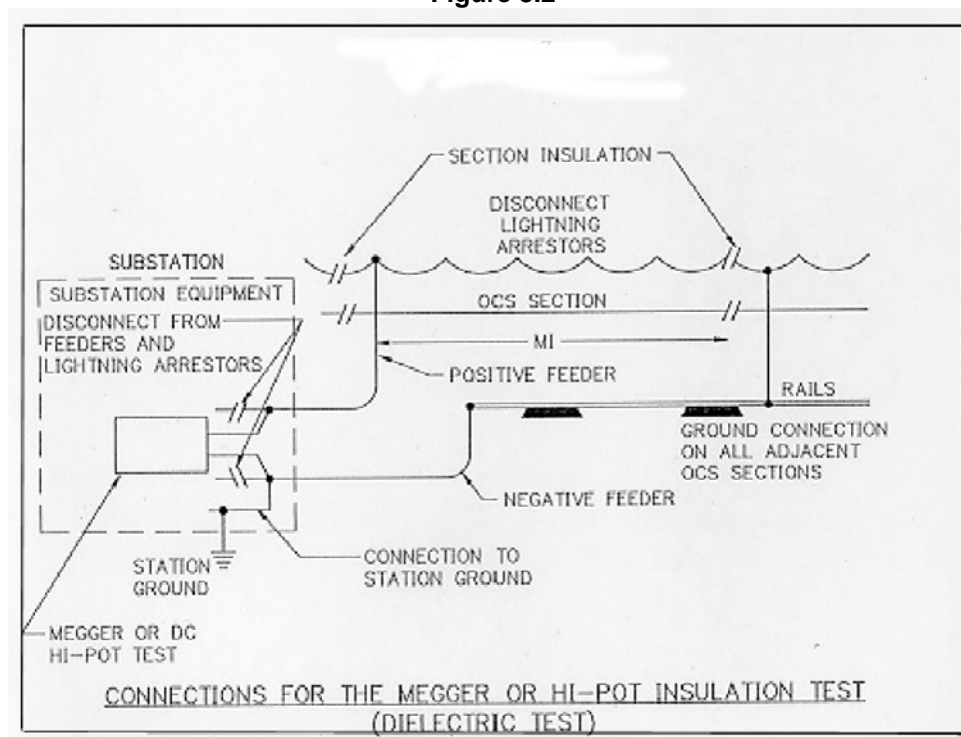
1. With the OCS de-energized, and with any surge arrestors disconnected, the Contractor shall connect a 1000 volt megger between the catenary and the rail at one end of each test section as shown in Figure 3.2. The resistance in each test shall be noted on Table 3.4. A resistance value of greater than 5 M ohms is required to be obtained before continuing with the tests described in the Hi-Pot Insulation Testing Section. The Contractor shall replace the 1000 volt megger with a dc hi-pot test set, and test for leakage current as described in the Hi-Pot Insulation Testing Section.

C. Hi-Pot Insulation Testing

1. DC Hi-pot test shall be performed on discrete sections 1 to 2 miles in length of the OCS.
2. A nominal Dc Hi-pot voltage of 2.5 kV shall be used for the test. Hi-pot tests shall be carried out on the OCS sections as soon as possible after the continuity tests have been completed, in order to ensure that all of the section being tested is electrically continuous and is subjected to the test voltage. Leakage currents between 0 and 5 mA can be expected for section lengths of 1-2 miles.

3. Precautions: The Hi-pot measurements require application of high voltage to the OCS. Proper regard must be paid to safety. Test zones shall be clearly identified. All safety requirements established in the Safety program concerning the public, work personnel and equipment shall be strictly enforced. Personnel not directly associated with the tests should be clear of the tracks. Sections of OCS and associated sections of the system, and all OCS sections adjacent to the section under test shall be grounded. Procedure: Adjacent OCS sections which are electrically isolated from the section under test shall be grounded by connecting the OCS to the rails. The Contractor shall verify that a low resistance path exists for all the rails between all grounds and the test ground connections. All surge arrestors shall be disconnected from the section under test. A dc voltage shall be applied to the OCS section in 500 volt steps up to 2500 V. Before each measurement is read, the Contractor shall allow one minute to pass in order to stabilize the level of leakage current. Leakage current shall not exceed 5 mA per mile at 2500 V. The Contractor shall record the results in Table 3.4. The cause of leakage currents in excess of 5 mA per mile, or unstable current readings shall be investigated. The test voltage shall be held for 30 seconds. The leakage current at each value shall be measured and recorded together with the weather conditions and temperature.

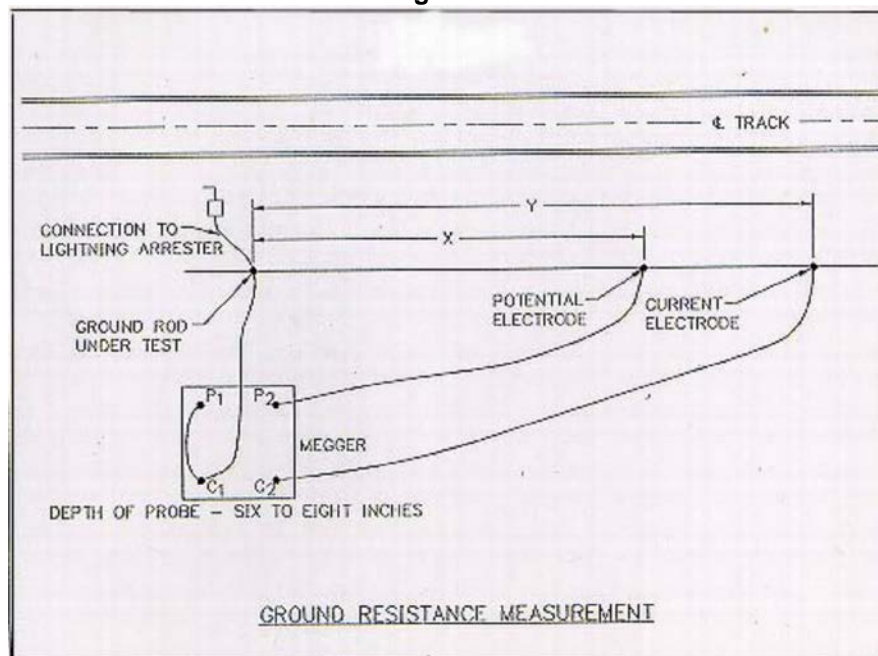
Figure 3.2



D. Ground Resistance Measurement for Surge Arresters

1. General: Prior to acceptance, the ground resistance of the ground connections for the surge arrestors shall be measured and recorded in accordance with the test procedure. Grounds for surge arrestors with a ground resistance measurement greater than 5 ohms shall be supplemented by adding ground rods until a grounding resistance of 5 ohms or less is achieved.
2. Procedure:
 - a. Connect the megger as shown in Figure 3.3. Note that the lead from P1C1 should be as short as possible and that the electrodes and the ground rod must be in a straight line. It is not essential for the electrodes to be parallel to the track, but this configuration will probably be the most convenient.
 - b. Position the electrodes at distances as shown in Table 3.2 test position 1, i.e. with $x = 66$ feet $y = 105$ feet. To ensure acceptance values of resistance, the ratio of distance (x/y) must be approximately 62 percent. Insert current and potential electrodes into the earth to about 6 to 10 inches, for very dry soil pour water around the current electrode. Measure and record the resistance.
 - c. Keeping the x dimension the same as in step b, reposition the current electrode to $y + 6$ feet. Measure and record the resistance.
 - d. Compare the resistance values obtained in steps 2 and 3. If the readings obtained are within 5 percent of each other, no further measurements are required and the average value should be used as the actual resistance. If the readings differ by more than 5 percent, increase x by ten feet and make y equal to $(x + 10) / 0.62$ approximately. Repeat steps 2, 3, and 4 as necessary.
 - e. Repeat this procedure for each surge arrester location for which a ground resistance measurement is required.
 - f. A measured ground resistance value of 5 ohm or less is considered acceptable.

Figure 3.3



PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

TABLE 3.1

TABLE 3.1 – ACCEPTANCE MEASUREMENT DATA

Line No.					b) Wire Run Number	c) Drawing No.		d) Names										e) Sheet No.				Remarks		
	a) Track				f) Equipment Style		g) Conductor Temperature:		h) Weather & Air Temperature				i) Date:		Overlaps & Turnouts Height of In-Running & Out-of-Running Contact Wire				Bridges					
	Structure				Mid Span				Balance weight								bb) Bridge Clearances				Type of Deck			
	j) Station No. Identification	k) Structure Setout face of pole to C/L track	l) Foundation Height above T.O.R. + or -	m) Crosslevel (Superelevation)	n) Stagger Looking upstation Right or Left	o) C.W. Height	p) ystem Height	q) Midspan Offset Looking upstation Right or Left	r) Midspan C.W. Height	s) Midspan Crosslevel (Superelevation)	t) Midspan SAG	u) Gradient	v) Span Length	w) Balanceweight Rise or Fall	x) Pos. of Balanceweight Stops	y) Mean BWA Position @ 600F	z) In-Running	aa) Out-of-Running	Approx. STA.	cc) Minimum Electrical Clearance M.W. to U/S deck at Bridge Face (F), Lowest point (L) or Mid Bridge (M)	dd) Bridge Vertical Clearance T.O.R. to U/S deck	ee) Minimum Electrical Clearance M.W. to U/S deck Dist. With 50 lbs. C.W. Uplift	Concrete (C), Concrete Encased (E), Prestressed Concrete (PSC) or Steel (S)	
	(ft)	(in)	(in)	(in)		(ft)	(in)	(ft)	(in)	(ft)	(in)	(in)	(in)	(ft)	(in)	(in)	(ft)	(in)		(ft)	(in)	(ft)	(in)	
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Remarks:																								



Table 3.2 GROUND RESISTANCE

ARRESTER LOCATION	TEST POSITION	DISTANCE X (ft.)	DISTANCE Y (ft.)	MEASURED GROUND RESISTANCE	AVERAGE GROUND RESISTANCE FOR STR. LOCATION
	1	66	105		
	2	66	111		
	3	76	122		
	4	76	128		

Tested By:

Date of Test:

Supervised By:

CM Witness:

TABLE 3.3 DC LOOP RESISTANCE
DATE TEMPERATURE WEATHER CONDITIONS

NO.	SECTION DESIGNATION	LENGTH (MILES)	VOLTAGE (V)	CURRENT (A)	LOOP RESISTANCE	
					TOTAL	PER MILE

1000V MEGGER RESISTANCE =

Tested By: _____ Date of Test: _____
Supervised By: _____
Witness: _____

Table 3.4 Hi-Pot Test

APPLIED VOLTAGE (V DC)	LEAKAGE CURRENT (micro Amps)
500 (HOLD 60 SEC.)	
1000 (HOLD 60 SEC.)	
1500 (HOLD 60 SEC.)	
2000 (HOLD 60 SEC.)	
2500 (HOLD 60 SEC.)	

LENGTH OF SECTION (MILES) =
LEAKAGE CURRENT PER MILE AT 2.5 KV =
NUMBER OF INSULATORS IN SECTION =
LEAKAGE CURRENT PER INSULATOR =

Tested by: _____

Date of Test: - _____

Supervised By: _____

CM Witness: _____

Technical Specification
SECTION 34 23 90
OCS INSTALLATION RECORDS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section covers the requirements for OCS installation records at site specific OCS support locations including As-built structure Record Drawings, OCS Wiring Layout Redline Drawings, OCS Materials List, Assembly "Used-on" List, Conductor Stringing Records, Cantilever Cutting Dimension Sheets and Test Reports.
- B. All electronic media shall be developed with a software format agreed to by the Engineer.

1.2 RELATED SECTIONS

- A. SECTION 01 33 00 – Submittal Procedures
- B. SECTION 34 23 96 – OCS Installation and Maintenance Manuals

1.3 SUBMITTALS

- A. Submittals shall be made in accordance with the requirements of SECTION 01 33 00 Submittal Procedures, except as modified herein.
- B. Samples of each type of OCS installation record shall be submitted to the Engineer within 60 days of Notice to Proceed.
- C. The first submittal of the As-built Structure Record Drawing shall be made in three drawing sets, clamped or bolted together, 11 x 17 inch size for review and comment by the Engineer.
- D. Final copies of the As-built Structure Record Drawing and Materials List shall be three copies 11 x 17 inch size in 7-ring binders or an Approved equal
- E. The final submittal of OCS Wiring Layout red-line "as-built" drawings shall be stamped "Project Record", signed and dated by the Contractor, and shall be delivered to the Project Manager prior to the final inspection.
- F. In addition to the requirements for hard copies of Contractor originated drawings, final copies of As-built Structure Record Drawings and Materials Lists shall be submitted in electronic format which shall include a matrix or document showing how the files are set up and how to access them. Include no extraneous files. Two CD ROMs shall be submitted.
- G. Two copies of Conductor Stringing Records and Cantilever Cutting Sheets shall be submitted to the Engineer.

PART 2 - PRODUCTS

2.1 AS-BUILT STRUCTURE RECORD DRAWINGS

- A. As-built Structure Record Drawings show the OCS as-built conditions at each location (stationing) where Work was performed by the Contractor.
- B. The Contractor shall provide an As-built Structure Record Drawing for each OCS pole/ OCS support location which may include one or more poles/ (bridge) supports.
- C. The Contractor originated drawings shall be developed in accordance with the Contract Drawings, and will show a photographic image of the final conditions at each location.

- D. The photographic image of the OCS poles shall depict the elevation taken from centerline of track, or thereabouts, facing in the direction of increasing stationing, and include the track rails and the complete structure and its constituent assemblies.
- E. Each structure photograph shall have an image that broadly fills the height of the available space on the As-built Structure Record Drawing.
- F. All photographs shall be taken at the highest quality and resolution level available on digital camera with at least 5.0 mega pixels capable of saving photographs on a non-glossy format like "TIFF".
- G. "Design" data (values and references) and "installed" data shall be shown in separate columns.
- H. Each column of data shall be for an individual wire run.
- I. The installed values for contact wire heights and staggers at supports shall be as measured by height and stagger gauge after remedial work has been completed.

2.2 OCS WIRING LAYOUT REDLINES

- A. The Engineer will furnish to the Contractor a complete set of OCS Wiring Layouts Drawings for redline purposes.
- B. The Contractor shall red-line the Wiring Layout Drawings to show any changes to the assembly references on a structure by structure basis. Wire heights and stagger values shall not be changed except at the direction of the Engineer.

2.3 OCS MATERIALS LIST

- A. The Contractor's proposed format of the computer generated Materials List and the "Used-on" List shall be forwarded to the Engineer prior to the submittal of the final documents.
- B. Assembly references given on Wiring Layout Drawings shall be totaled by computer and issued by the Contractor in tabular form as follows:
 - 1. Materials List - By site specific OCS pole/OCS support location (stationing) showing every assembly required for complete installation of the support and of the span ahead
 - 2. "Used-on" List - By assembly reference, showing every support location (stationing) where the specific assembly is used

2.4 OCS CONDUCTOR STRINGING RECORDS

- A. For each length of conductor installed, a detailed record shall be kept of:
 - 1. The reel number from which the conductor was taken
 - 2. The maximum prestressing tension applied
 - 3. The temperature at the time of tensioning
 - 4. The time period that the prestressing was applied
 - 5. Certifying signature of the Contractor's Superintendent/Engineer/Construction Manager

2.5 CANTILEVER CUTTING SHEETS

- A. For each cantilever, the dimensions of the pipes and other components shall be shown on Cantilever Cutting Sheets.

2.6 TEST REPORTS

- A. Test Reports initiated by the Contractor or by the Engineer and prepared by the Contractor shall be treated in accordance with SECTION 01 33 00 – Submittal Procedures.

PART 3 - EXECUTION

Not Used

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 34 23 96 OCS INSTALLATION AND MAINTENANCE MANUALS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section describes the Work and format required to produce Overhead Contact System (OCS) Installation and Maintenance (I&M) Manuals.
 - 1. All OCS I&M manuals shall comprehensively address Overhead Contact System assembly configurations, assembly/component maximum loads, OCS installation precautions, conductor stringing, initial creep removal, final adjustments, preventive maintenance, servicing, repair and spare parts provisioning. Include information for routine OCS inspections and quantitative OCS measurements. Include OCS assembly replacement with the OCS energized and de-energized.
 - 2. OCS I&M Manuals shall be prepared in separate sections addressing:
 - a. OCS wiring and poles
 - b. OCS shop drawings, assembly references, components and conductors
 - c. Spare parts catalogs
 - d. OCS disconnect switches

1.2 RELATED SECTIONS

- A. SECTION 01 33 00 – Submittal Procedures
- B. SECTION 34 23 97 – OCS Maintenance Staff Training

1.3 QUALITY ASSURANCE

- A. Provide qualified manual writers and developers who are thoroughly familiar with all subject material for each volume.

1.4 SUBMITTALS

- A. Submittals shall be made in accordance with the requirements of SECTION 01 33 00 SUBMITTAL PROCEDURES, except as modified herein.
- B. The Contractor shall submit the following:
 - 1. One complete photo-ready reproducible hard copy of each volume of the I&M Manual.
 - 2. One all-electronic media version of the complete manual on compact disc using MS Windows compatible files in with a software format mutually agreed upon with the Engineer.
 - 3. Electronic media versions revised in accordance with hardcopy manual revisions, during the review period
 - 4. Submit five copies of I&M Manuals in final form.

1.5 SUBMITTAL SCHEDULE

- A. The Contractor, at a minimum, shall submit to the Engineer for Approval the following, in accordance with the following timetable:
 - 1. OCS I&M Manual Outline – Submit two sets of manual outlines with a submittal schedule to the Engineer for Approval, at least 1 year before the start of the prescribed training courses specified in SECTION 34 23 97 OCS MAINTENANCE STAFF TRAINING.
 - 2. OCS I&M Manual, Draft - Submit two sets of the first draft of the proposed training materials 6 months before the start of the prescribed agency training course.
 - 3. OCS I&M Manual Training Draft - Submit ten sets of the training draft for use during the training class, 30 days before the start of the prescribed agency training course.
 - 4. OCS I&M Manual, Final - Submit final volumes of the I&M Manuals in the following quantities 30 days after the completion of training:
 - a. Three complete sets of manuals in reproducible hard copy format
 - b. One electronic copy in native format
 - c. One electronic copy in Adobe PDF format
 - d. The final submittal of materials shall correct all errors that were found by the Contractor, found during training or changes that were requested by the Engineer.
- B. All revision updates for all volumes of the OCS I&M Manual shall be provided to the Engineer by the end of the Warranty period or more frequently to reflect any changes made to the OCS during the Warranty period.

1.6 MANUAL CONTENT

- A. The I&M Manual shall cover, but not be limited to the following OCS topics:
 - 1. Overhead Contact System description
 - 2. Section insulators
 - 3. Disconnect switches
 - 4. Poles
 - 5. Surge arresters
 - 6. Cantilever assemblies
 - 7. Headspan assemblies
 - 8. Single wire cross span assemblies
 - 9. All splice types
 - 10. Maintenance and inspection special tools
 - 11. Operations and Maintenance Procedures
 - 12. Safety Precautions

PART 2 - PRODUCTS

2.1 MANUAL FORMAT

- A. Manuals shall consist of 8 1/2 x 11 inch sheets bound in loose-leaf 7-ring type binders. Binders shall not exceed 3 inches overall thickness. Several binders may be required.
 - 1. Foldout diagrams or illustrations may be employed with a maximum size of 11 x 17 inches. The title shall be visible when the sheet is folded.
 - 2. Covers shall be oil, grease, solvent and wear resistant.
 - 3. The paper and ink shall resist smearing, fading and deterioration from age.
- B. The organization of the manuals shall treat the OCS as a system and not as a grouping of disassociated parts. The manuals shall highlight the precautions to be taken by operating and service personnel to assure their safety while performing maintenance, and servicing functions.
- C. Manuals shall be written in English to be understood by a high school graduate with 2 years of experience in a related field but with minimal knowledge of railroad or transit operations. The writing shall be concise and free of ambiguities.
- D. Manufacturer's standard manuals and parts lists will be acceptable, subject to the approval of the Engineer, if they deviate only slightly from the requirements specified herein.
- E. Revisions to a manual shall be reflected in a revision index, which shall form an integral part of each manual and which shall be revised with each manual update.
- F. Diagrams and illustrations shall not be loose or in pockets. All printed material shall be clearly reproducible by copying machines, which precludes the use of halftone illustrations (line drawings are required).
- G. The material in the manuals including the spare parts catalogs shall be similarly organized and indexed, with a standard numbering system. The format of all data contained in the manuals shall be consistent section to section.

2.2 PURPOSE

- A. The OCS I&M Manual shall enable the maintenance staff to have, in convenient form, all information needed for preventive maintenance inspections, maintenance tasks, adjustment and installation, and on-site trouble diagnosis.
- B. It shall also contain a detailed description of each system component so that the maintenance staff can effectively service, inspect, maintain, adjust, troubleshoot, repair and replace it.
- C. An integrated set of OCS shop drawings shall be included as a separate section. All portions of the drawings shall be legible when printed on 8 1/2 x 11 inch paper.
- D. Include in the manual:
 - 1. General description
 - 2. Principles of operation
 - 3. Shop drawings to component level
 - 4. A conductor schedule listing installation details of every contact wire by wire run number
 - 5. Preventive maintenance tasks and procedures highlighting critical areas requiring meticulous attention for inspection and maintenance standards including wear limits, settings and tolerances

6. Lubrication and cleaning, including frequency, methods, and trade identifications of recommended materials, component location and description
7. Summarized preventive maintenance schedules and recommended intervals
8. Repair procedures including dismantling, reassembly and testing procedures
9. Requirements of special tools, jigs, stagger and clearance gauges and their source of supply
10. Test equipment lists and their description
11. Spare parts requirements
12. Warning and safety procedures during maintenance actions
13. A description of OCS assemblies and assembly references
14. Standard installation procedures
15. Safety procedures
16. List of special tools that are required for any given installation
17. Any other information necessary to ensure proper installation and as required by the Engineer

2.3 SPARE PARTS CATALOG

- A. The spare parts volume of the I&M Manual shall catalog, enumerate, and describe every component with its related parts and necessary special tools, including the supplier's number and any commercial equivalents.
- B. Drawings shall identify all sub-assemblies and component parts. A component part is defined as the lowest level of component assembly that consists of a separate individually fabricated part.
- C. Parts common to different components (e.g. bolts and nuts) shall bear the same Contractor's number in all components with a reference to the other components in which they are used. Each part or other component shall be identified as being part of the next higher assembly.
- D. Commonly available material such as galvanized pipe, galvanized and stainless steel wires and rods, nuts and bolts, thimbles etc. shall be identified by standard hardware nomenclature and the Contractor's number. A separate list of these items shall be provided in the manuals with information sufficient to order these items through (local) commercial channels.
- E. The spare parts catalog shall have a complete itemization of all consumable parts and servicing materials (oils, paints, special compounds, grease, etc.) required for the component requiring its use.
- F. Federal Paint Registry Numbers shall be supplied in addition to paint descriptions as part of the itemization of consumables
- G. In addition to the normal cross-referencing noted in the preceding paragraphs, at least three supply sources shall be provided for all required consumables and servicing materials. Suppliers and materials shall be specified by trade name and type. Of the three required sources, at least two shall be located in the United States

PART 3 - EXECUTION

Not Used

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 34 23 97 OCS MAINTENANCE STAFF TRAINING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes Specifications for training materials, training programs and training schedules for the Overhead Contact System (OCS).
 - 1. The Contractor shall complete all OCS training 30 days prior to the start of OCS Commissioning.
 - 2. Training classes shall be for OCS trainees between entry level and Journeyman.
 - 3. The Contractor shall furnish manuals, training literature and training aids for OCS training.
 - 4. Training and support materials shall be provided to enable the agency personnel to operate and maintain the complete OCS. The training program shall include detailed instructions, demonstrations and supervised hands-on training.
 - 5. Each OCS trainee class shall be given twice. The Contractor shall coordinate with the Engineer during the scheduling of the training classes so that the agency only has to provide 50% of the OCS maintenance/operations staff at any one given time. Depending on the agreed upon schedule, the duplication requirements for classes may require a periodic gap of time between classes.
 - 6. Each class shall be developed with the Engineer, with the objective of the agency being able to repeat training for OCS trainees at a later date.
 - 7. All training shall be given in English, unless otherwise requested/coordinated by the Owner..
 - 8. The agency shall retain the right to reproduce any of the training materials for its own use.

1.2 RELATED SECTIONS

- A. SECTION 01 33 00 – Submittal Procedures
- B. SECTION 34 23 90 – OCS Installation Records
- C. SECTION 34 23 96 – OCS Installation and Maintenance Manuals

1.3 DESCRIPTIONS

- A. Element – A Systems Element, i.e. OCS, Communications, Corrosion, Signals or Traction Power
- B. Topic – A subject area within OCS, for which instruction will be completed in less than 4 hours.
- C. Instructor – A Contractor's employee nominated to give training
- D. Trainee – An agency employee receiving training
- E. Agency OCS Trainers – An agency employee selected to teach trainees
- F. Student – A trainee or agency OCS Trainers attending a class of instruction
- G. OCS Training Materials – This describes the OCS documents used in support of the classroom and workshop instruction, and comprises:
 - 1. OCS Instructors Training Guide

2. OCS Training Aids
 3. OCS Student Workbooks
 4. OCS Trainers Handbook
- H. OCS Support Materials – As-built documentation of the installed OCS, including updated Contract Drawings, acceptance measurements forms, cantilever cut sheets, a photographic record of every OCS support and the OCS I&M Manuals.
- I. OCS Instructors Training Guide – Used as a manual by OCS Instructors and the agency OCS trainers, this Guide includes a course outline, agendas, objectives, lesson plans, training aids, presentation guidelines, suggested questions for class discussion, and criteria for measuring student performance.
- J. OCS Training Aids include:
1. Visual displays (overhead transparencies, Power Point files)
 2. OCS assemblies and components
 3. Scale models
 4. Mock ups
 5. Tools and equipment
- K. OCS Student Workbooks – These workbooks for trainees include a course agenda, a schedule of sessions, hard copies of presentations (e.g. transparencies, electronic presentation files), lecture outlines, and any additional printed material used during the course.
- L. OCS Trainers Handbook – This Handbook for OCS Trainers expands on the subject matter given in the Instructors Training Guide by showing additional examples, photographs, charts and tables. Answers to questions on aspects of OCS raised by the trainees in previous classes are included. The OCS Trainers Handbook also gives assistance in the use of training aids provided by the Contractor.
- M. OCS Installation and Maintenance Manual – typically comprising sections on pole and wiring installation, shop drawings, OCS spare parts and details on disconnect switches.

1.4 TRAINING

- A. Training shall be conducted at the agency facilities in El Paso, Texas and include classroom and hands-on instruction for agency personnel.
- B. The size of OCS trainee classes, time and location for the training shall be Approved in advance by the Engineer.
- C. Instructors shall conduct customized training classes on OCS topics.
- D. Instructors shall be capable of providing detailed explanations of the operation and maintenance of all aspects of OCS, including individual assemblies, and of answering any questions that may arise.
- E. The Contractor shall furnish experienced instructors who have direct knowledge of OCS.
- F. For each class, Instructor(s) shall have previously conducted classes of similar subject matter and scope, and shall be proficient in the use of the tools, equipment and training aids.
- G. The resumes and qualifications of OCS instructors shall be submitted to the agency for Approval.
- H. A list of the OCS topics to be taught by each instructor shall be submitted in advance to the Engineer.

- I. All instructors shall be fluent in English. Prior to the initiation of classroom instruction, all instructors nominated by the Contractor shall attend a 1-day orientation at the agency to become familiar with agency safety regulations and facilities, and to be advised of student qualifications and expectations.
- J. The Contractor shall furnish a description of the prerequisite knowledge trainees must have before starting OCS training classes.

1.5 SUBMITTAL QUANTITIES FOR FINAL OCS TRAINING MATERIALS

- A. The Contractor shall provide the following final training materials:
 - 1. One complete photo-ready reproducible set of OCS Instructor Training Guide, OCS Trainers Handbook, and Student Workbook
 - 2. All training materials that are produced for the Project shall be MS Windows compatible files, using a software format mutually agreed between the Engineer and the Contractor. The electronic media versions shall be revised in accordance with the hardcopy manual revisions.
 - 3. Two OCS Instructors Training Guides
 - 4. Two OCS Trainers Handbooks
 - 5. One complete set of training aids
 - 6. Ten student workbooks
- B. A schedule for delivery of training materials to all designated the agency personnel shall be approved in advance by the Engineer.

1.6 SUBMITTAL SCHEDULE

- A. The Contractor, at a minimum, shall submit to the Engineer for Approval, in accordance with SECTION 01 33 00 Submittal Procedures OCS Training Outline Proposals and OCS Training Materials, in accordance with the following timetable:
 - 1. OCS Training Outline Proposals – Submit two sets of training outlines/schedules. The outline/schedule shall be submitted to the Engineer for Approval, at least 1 year before the start of the prescribed agency training courses.
 - 2. OCS Training Materials, Draft - Submit two sets of the first draft of the proposed training materials 6 months before the start of the prescribed agency training course.
 - 3. OCS Training Materials, Training Draft - Submit ted sets of the training draft for use during the training class, 30 days before the start of the prescribed agency training course.

4. OCS Training Materials, Final - Submit final training materials in the following quantities 30 days after the completion of training:
 - a. Three complete sets of manuals in reproducible hard copy format
 - b. One electronic copy in native format
 - c. One electronic copy in Adobe PDF format
 - d. The final submittal of training materials shall correct all errors that were found by the Contractor, found during training or changes that were requested by the Engineer.
- B. All revision updates for all the training materials shall be provided to the agency by the end of the Warranty period or more frequently to reflect any changes made to the OCS during the Warranty period.

1.7 INSTRUCTION REQUIREMENTS

- A. Trainees shall be exposed to the depth of detail that is necessary for the performance of preventive, corrective, overhaul and maintenance operations for all OCS equipment supplied under this Contract.
- B. Trainees shall be afforded the opportunity to perform the more complex maintenance functions in the field and in the shop, in addition to troubleshooting faults artificially introduced in the equipment.
- C. Instruction shall include, at a minimum, the following:
 1. Introduction to the equipment, including terminology, and the identification of OCS assemblies
 2. The OCS Wiring Layouts drawings showing the configuration of the OCS over the tracks
 3. Theory of design of an OCS.
 4. Routine care, including cleaning, lubrication schedules, adjustments and inspection criteria
 5. Problem symptoms, troubleshooting techniques and repair procedures
 6. Removal and replacement of components
 7. Disassembly and reassembly for the purpose of component familiarity and any special processes
 8. When methods of access, removal, dismantling, or application are not self-evident, the instruction shall cover these matters
 9. Instruction in the use and maintenance of all OCS special tools and gauges
 10. Safety instruction for all maintenance activities
 11. Overhaul procedures

1.8 TRAINING OUTLINES

- A. The Contractor shall develop and provide a training outline proposal for agency Approval 1 year in advance of the scheduled training.
- B. The Contractor training outline shall include:
 - 1. A list of OCS training topics
 - 2. A detailed outline of each topic
 - 3. A description of the scope of instruction to be covered in each topic
 - 4. An overview of the hands-on experience to be included as a part of the OCS training course
 - 5. A list of the OCS equipment, tools and test equipment, manuals, and other materials to be utilized as trainee training aids
 - 6. Lesson plans that include the sequence of activities, an outline of the content, the learning strategies to be used (e.g., classroom presentation, hands-on practice, audio/video presentation, etc.), and include sample lessons
 - 7. An assessment of the classroom space, workshop space and power supplies needed for training
 - 8. A list of classroom equipment that agency might loan if requested
 - 9. The duration of the training, in hours, for each topic, broken down into classroom, workshop and fieldwork
 - 10. A proposed course schedule

1.9 OCS TRAINING MATERIALS

- A. Training materials shall be separate and distinct from the Contract As-built records and I&M Manuals. Training materials shall be setup to contain step-by-step introduction to the OCS training classes and shall describe those features and equipment peculiar to OCS.
- B. As training materials are being developed, the Contractor shall work closely with agency staff, to ensure the specified agency standards with respect to the course organization, content, and overall quality of all training materials are being met.
- C. The Contractor shall provide an adequate supply of high quality, professionally prepared training material on paper, and such other training aids as described in this Section, to impart the essential knowledge to the trainees involved and leave them with authoritative and up-to-date reference material.
- D. Training materials shall provide support to the training courses, and comprise the OCS Instructors Training Guide, OCS training aids, and OCS student workbook.

1.10 OCS INSTRUCTORS TRAINING GUIDE

- A. The Contractor shall provide Instructors Training Guides for Contractor's instructors and for agency OCS trainers, containing course outline, agendas, objectives, lesson plans, training aids, presentation guidelines, suggested discussion questions and criteria for measuring student performance by a series of tests.
- B. The information given in the Instructors Training Guide shall be coordinated with course information and course materials, and shall be grouped to correspond to course periods of not more than 4 hours.

- C. Written and practical tests shall be included, that are to be given at suitable points during training. These tests shall be designed to determine the extent to which students have learned and can apply the information presented.

1.11 TRAINING AIDS FOR OCS TRAINEE CLASSES

- A. The Contractor shall provide training aids for use by the OCS instructor, such as mock-ups, scale models, and electronic presentations (e.g. Microsoft Power Point files) etc. The following materials may be used as training aids:
 - 1. Items that are ear-marked for spare parts may be used to facilitate hands-on-training in a workshop setting or out on the line.
 - 2. OCS assemblies such as section insulators, shop-door bridges, lightning arresters, disconnect switches and pantographs, the functions of which can be displayed without dismantling.
 - 3. Electronic presentation files (software format to be approved by agency or videos shall be used for training aids. Electronic presentation files may be used to illustrate OCS assemblies showing components, and OCS wiring layouts.
 - 4. Lesson plans shall be updated as required during the course of instruction.
- B. All training aids shall be of durable construction and shall become the property of the agency. Any equipment or tools used during training are in good working condition both before and after training sessions.
- C. All training materials, such as training aids and lesson plans, shall become the property of the agency at the completion of the training program. The Contractor shall be responsible for the condition of these materials for the duration of the training program.
- D. Where videos are used for instruction, one copy of each instructional video shall be provided to the agency on a DVD.
- E. Course materials (e.g. manuals, class handouts, tools, equipment, videos, computer-based software) and training materials shall be provided for each class, and shall be reusable (where practical). The same training materials shall be used for each class so that each class is exposed to the same information and comments can be collected on training manuals. Comments from training manuals will be given to the Contractor for incorporation into the final manuals.

1.12 OCS STUDENT WORKBOOKS

- A. The Contractor shall provide student workbooks for OCS trainees that include:
 - 1. Course objectives
 - 2. A course agenda
 - 3. Schedule of sessions
 - 4. Lecture outlines
 - 5. Instructions on use of course materials, tools, equipment and other instruction aids
 - 6. Notebook-size, 8 1/2 x 11 inch, copies of all visual displays used by an instructor, (e.g. electronic presentation files)
- B. The student workbook shall include prepared notes on:
 - 1. Design and operation of the OCS

2. The interaction between OCS and other System Elements, such as traction power, signals and corrosion
 3. Civil trackwork, overhead bridges and underpasses impacting the design and maintenance of the OCS
 4. The relationship of the OCS wiring layouts and the assembly reference drawings/shop drawings
 5. Contract OCS as-built drawings and other installation records
 6. The content and use of the procedures in the OCS I&M Manuals
 7. OCS test equipment
 8. The calibration and regular checking of stagger gauges and clearance envelope carts
 9. Use and analysis of Acceptance measurements sheets
 10. Hook-up video equipment for OCS surveillance runs
- C. Student workbooks shall be retained by the trainees for future reference.
- D. Student workbooks shall be printed single sided and presented in 3-ring binders. This will allow room for students to use the blank sides of pages for notes.

1.13 OCS CONTRACT DRAWINGS

- A. OCS Contract Drawings include both basic design drawings and site-specific drawings. On completion of the installation these drawings are updated to an As-built or a Design Update condition.
1. For use in class (in the absence of screen projection) these drawings shall be reproduced in two sets: a BASIC DESIGN set and a SITE-SPECIFIC set at 11 x 17 inch size.
 2. For distribution to each trainee the two sets shall be reproduced at 8 1/2 x 11 inch and comb-bound.

1.14 OCS INSTALLATION AND MAINTENANCE MANUALS

- A. I&M Manuals, (also called Installation and Maintenance Manual), typically comprise the following volumes:
1. OCS wiring and poles
 2. OCS shop drawings, assembly references, components and conductors
 3. Spare parts catalogs
 4. OCS disconnect switches
- B. These volumes shall be available for training purposes, and such a set shall be made available to the training class. See SECTION 34 23 96 OCS Installation and Maintenance Manuals.

1.15 AMOUNT OF REQUIRED TRAINING TIME FOR OCS TRAINEES

- A. The Contractor shall designate the total number of hours allocated for training of two classes with a class size of up to ten people.
- B. The Contractor shall provide two classes with up to ten agency employees per class for OCS training at 40 hours for each class = 80 hours total for OCS training.

1.16 TRAINING SYLLABUS FOR THE TRAINEES COURSE

- A. The Contractor shall develop a course syllabus covering the following topics and allowing time for the trainees to interact with the Instructor during the instruction by asking questions and receiving input based on real life experiences. Where appropriate the instructor shall address typical misinterpretations by novices of criteria and of equipment factors of safety. Showing of Video/DVD recordings is encouraged. Field visits shall be included where practical. Time for short written tests during class time shall be allowed.
- B. The following shall provide a framework for the order of the topics to be taught and times shown are typical values and may be varied, but the sequence of the classes and their duration is at the Contractor's choice, but subject to the Engineer's Approval:
 - 1. Introduction to OCS (class room)
 - a. Glossary of OCS Terms
 - b. Description of OCS styles
 - 2. OCS Design Basis (class room and field)
 - a. Agency Design Criteria (all Sections)
 - b. Streetcar Characteristics
 - 1) Vehicle envelopes
 - 2) Pantographs
 - 3) Pantograph clearance envelopes
 - c. Conductors and wires
 - 1) Types and uses
 - 2) Tensions and sags
 - d. Contact wire stagger design
 - 1) Track tolerances
 - 2) Vehicle and pantograph sway
 - 3) Wind effects
 - 4) Mid-span offset
 - e. Contact Wire Height
 - 1) In streets and segregated right-of-way (ROW) (NESC)
 - 2) Clearance at overpasses
 - 3) Track sags and hogs
 - 4) Contact wire gradients
 - f. Clearance Criteria
 - 1) Electrical
 - 2) Physical (Code)

3. As-built Records, as described in SECTION 34 23 90 OCS Installation Records.
 - a. OCS Contract Design Update Drawings (class room)
 - 1) Drawing hierarchy
 - 2) Basic design drawings
 - 3) Site specific drawings
 - b. OCS Testing and Measurements Records (class room and field)
 - 1) OCS acceptance measurements
 - 2) Pole ground resistance measurements
 - 3) Pantograph clearance envelope checks
 - 4) Streetcar OCS videotapes
 - 5) Structure record drawings
4. Installation and Maintenance Manuals (I&M), as described in SECTION 34 23 96 OCS Installation and Maintenance Manuals (class room)
 - a. OCS wiring and poles
 - 1) Conductor stringing
 - 2) Preventive maintenance
 - b. OCS shop drawings, components and conductors
 - c. OCS parts catalog
 - d. OCS disconnect switch
5. Shop Work
 - a. Cantilever manufacture
 - b. Pull-off assembly
 - c. Hanger manufacture
 - d. Other assemblies
6. Periodic Inspections of the OCS
 - a. Quantitative Measurements (class room and field)
 - 1) Wire heights and staggers
 - 2) Track elevation and superelevation
 - 3) Analysis of height and stagger measurements
 - b. Qualitative Inspections (class room and field)
 - 1) Eye-level inspections
 - 2) Ground-level inspections

- 3) OCS surveillance by video
- 7. Reasons for OCS Line Failures (class room)
 - a. Dewirements
 - b. Lightning strikes
 - c. Vandalism
 - d. Faulty materials
- 8. Hi-Rail Vehicles (class room and field)
 - a. Use
 - b. Maintenance
- 9. OCS Tools, Equipment and Gauges (class room and field)
 - a. Stagger gauges
 - b. Pantograph clearance gauge
 - c. Video equipment
 - d. Tensiometers
 - e. De-kinking tools
 - f. Lifting equipment and slings
 - g. Work/worker safety
- 10. Agency Operations and Maintenance Procedures (class room)

1.17 SPECIAL EQUIPMENT FOR OCS TRAINING CLASSES

- A. The Contractor shall, at a minimum, supply one complete set of all special tools and test equipment necessary to service, repair, maintain, and overhaul each system shall have been delivered by the Contractor for use in the training program. At the completion of the training program these special tools, test equipment, and training aids shall be turned over to the Engineer, in proper working order, by the Contractor.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

END OF SECTION

Technical Specification

SECTION 26 24 90 BASELINE AND REVENUE STRAY CURRENT TESTING

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. The Contractor shall perform two studies: a baseline stray current study (baseline) and revenue service stray current study (revenue) on various structures throughout the alignment including those of the Camino Real Regional Mobility Authority (CRRMA) and adjacent utility and other structures. This work shall include the measurement of the structure-to-earth potential, corrosion rate electrical resistance, stray current flow on structures identified in the proposed test plan to be prepared by the Contractor, and all other measurements defined herein. The measurement of the parameters for the baseline study shall be taken after substantial completion of the traction power, OCS and track systems, but prior to the energization of the streetcar traction power substations. The revenue study shall be performed after the streetcar system has been in revenue service operation, carrying passengers, for no less than three months.
- B. The baseline study shall include the performance of the following tests:
 - 1. Any yard water pipeline electrical continuity, current flow and pipe-to-earth potential;
 - 2. Any yard natural gas pipeline electrical continuity, current flow and pipe-to-earth potential; and
 - 3. Structure to earth potentials on no less than 10 and no more than 20 representative utility or other structures selected by the CRRMA along the alignment.
- C. The revenue study shall include the performance of the following tests:
 - 1. Structure to earth potentials on the same utilities and structures that are monitored during the baseline study; and
 - 2. Long term (24 hour minimum) recordings to identify changes in the structure-to-earth parameters measured due to Streetcar activity when compared to the data recorded during the baseline study.
- D. Related Documents: The following Documents contain requirements that may relate to this Section:
 - 1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 RELATED SECTIONS

- A. SECTION 26 05 00 – Common Work Results for Electrical

1.3 REFERENCES

- A. American Society for Testing and Materials (ASTM)
 - 1. ASTM G165 Track-to-Earth Resistance Testing
- B. NACE, International (NACE)
 - 1. SP0169-2007, Control of External Corrosion on Underground or Submerged Metallic Piping Systems
 - 2. SP0286-2007, The Electrical Isolation of Cathodically Protected Pipelines

C. Institute for Electrical and Electronics Engineers (IEEE)

1. IEEE-81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
2. IEEE-81.2, Guide for Measurement of Impedance and Safety Characteristics of Large, Extended or Interconnected Grounding Systems

1.4 SUBMITTALS

A. Test Plan

1. The Contractor prepared test plan shall be submitted at least 60 days prior to the anticipated start date of the baseline study and approved prior to any work being performed.
2. The test plan shall include the following information for both the baseline and revenue testing efforts:
 - a. Test procedures for each test to be conducted;
 - b. Location maps for test locations;
 - c. Equipment list for all equipment to be used;
 - d. Current certifications for all equipment calibration;
 - e. Certifications for each individual who will work on this project that demonstrate that each proposed testing personnel has appropriate corrosion control and stray current experience as defined herein; and
 - f. Resumes for each individual who will work on this project demonstrating appropriate experience and qualifications as defined herein.

B. Schedule

1. Thirty (30) days prior to the start of testing for each phase (baseline and revenue), a schedule shall be provided by the Contractor to indicate start date, working hours, working locations, finish date, report preparation duration and report submittal date so the CRRMA can coordinate site visits and review periods.
2. The schedule shall include the complete duration for each task for each phase of the project (baseline and revenue).
3. Any proposed deviations from the schedule shall be brought to the attention of CRRMA as soon as possible to minimize conflicts in project scheduling.

C. Baseline Stray Current Report

1. The Contractor shall provide a baseline report no more than 30 days after completion of the field-testing according to the approved schedule.
2. The baseline report shall contain a cover letter, all data obtained in a tabulated form, drawings showing test locations to allow for repeatability of all measurements, all raw data sheets, and all other documentation to allow complete review of the information obtained.

D. Revenue Stray Current Report

1. The Contractor shall provide a pre-revenue stray current report no more than 30 days after completion of the field-testing according to the approved schedule.
2. The revenue report shall contain a cover letter, all data obtained in a tabulated form, drawings showing test locations to allow for repeatability of all measurements, all raw data

sheets, specific discussion and conclusions of the revenue data compared to that recorded during the baseline tests, and all other documentation to allow complete review of the information obtained.

1.5 QUALITY ASSURANCE

A. General

1. All work shall be performed to the satisfaction of CRRMA.
2. All work shall be performed by an experienced and independent corrosion control firm specializing in underground and stray current corrosion control and testing.

B. Qualifications

1. The independent corrosion control firm shall have the following minimum qualifications:
 - a. Registered Corrosion Engineer, NACE International Certified Corrosion Specialist, or NACE International Certified Cathodic Protection Specialist available to manage this corrosion control Project.
 - b. NACE International Certified Cathodic Protection Specialists and Corrosion Technicians available to perform the required field-testing.
 - c. A minimum of five years' experience in the testing of baseline and revenue stray current measurements.

C. Equipment: All equipment to be used for baseline and revenue testing shall bear current calibration stickers. Current calibration certificates shall be maintained by the Contractor in El Paso for all equipment to be used for this testing.

D. Verification: The performance of all stray current testing procedures may be witnessed by the CRRMA to verify compliance with the proposed procedures and with the Contract Documents.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

- A. Recording voltmeters or similar type of equipment shall be utilized to record the voltage and current measurements. The Contractor shall include recordings in the baseline and revenue reports along with all other data obtained.
- B. The electrical measurements taken on structures shall comply with the standard practices of the referenced documents and with the following:
 1. All structure-to-earth potential measurements shall utilize a standard copper copper-sulfate reference electrode for the ground connection or the permanent reference electrode installed with the test facilities.
 2. If the permanent reference electrode is other than a copper copper-sulfate reference electrode the potential must be referenced to a copper copper-sulfate reference electrode.
 3. All structure-to-earth potential and current flow measurements shall be measured for a minimum duration of 15 minutes to capture any time dependent variations.
 4. Any structure-to-earth potential and current flow measurements that show excessive variation shall be recorded over a 24-hour period.

5. Graphical output of all recordings shall be included with the baseline and revenue reports.

3.2 BASELINE STRAY CURRENT MEASUREMENTS

- A. The Contractor shall perform baseline stray current measurements; these measurements shall include, but not be limited to, the following for each structure identified:
 1. Structure-to-earth potential.
 2. Electrical continuity.
 3. Current flow.
 4. Cathodic protection parameters.
 5. Insulating joint effectiveness.
- B. Baseline stray current testing shall be conducted after substantial completion of the traction power, OCS, and track systems but prior to energization of any traction power substation along the Project.

3.3 REVENUE STRAY CURRENT MEASUREMENTS

- A. The Contractor shall perform revenue stray current measurements for all structures identified for baseline stray current measurements. The structures tested for baseline stray current measurement shall be re-measured subsequent to start of revenue service to identify changes to the levels identified during the baseline testing.
- B. The revenue stray current measurements shall include, but not be limited to, the following for each structure:
 1. Structure-to-earth potential.
 2. Electrical continuity.
 3. Current flow.
 4. Cathodic protection parameters.
 5. Insulating joint effectiveness.
- C. The intent of the measurements is to identify changes in the operating conditions related to the transit System operation from that documented during the baseline tests. This will require 24-hour recordings of structure to earth potentials and current flows on structures showing stray current interference during local streetcar operations. All structure to earth potential and current flow measurements must include at least one local load passing the test location. The revenue tests shall be performed after the streetcar system has been in revenue service operation, carrying passengers, for no less than three months.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Not Used

4.2 PAYMENT

Not Used

URS Corporation
TBPE Firm Registration No. F-3162

SPECIAL SPECIFICATION**EP-STOPS****Streetcar Stop Furnishings**

1. **Description.** This work consists of supplying and installation of streetcar stop furnishings as indicated within this specification and the plans.
2. **Materials and Measurement.**
 - A. **Shelters.** Furnish and install shelters at stop locations as field located by the Owner or Owner's Representative. Shelters shall be structurally supported cantilevered roof canopy sections of approximately 100" height to apex of roof of canopy, 180.5" length, 65" width and shall conform to the performance and specification requirements of <http://www.brasco.com/> Type Eclipse – cantilever or equal as approved by Sun Metro. Shelters will be measured by each shelter complete in place and will include all necessary materials, foundations, equipment and labor to complete per Manufacturer instructions.
 - B. **Benches.** Furnish and Install benches as shown on the plans. Submit bench product data for approval. Benches will be measured by each bench complete in place and will include all necessary materials, foundations, equipment and labor to complete per plans.
 - C. **Leaning Rail.** Furnish and install Leaning Rail as shown on the plans. Submit shop drawings and product data for approval. Leaning Rail will be measured by the linear foot and include all necessary materials, foundations, equipment and labor to complete per plans.
 - D. **Barrier Rail/Handrail.** Furnish and install ADA compliant pedestrian handrail in accordance with TxDOT Standard Detail PRD-13. The handrail will meet the requirements of Texas Department of Transportation Specification Item 450 "Railing". Handrail will be measured by the linear foot and will include all necessary materials, foundations, equipment and labor to complete per plans.
 - E. **Detectable Warning.** Construct Detectable Warning (Cast-in-Place) as indicated on the plans and details. Materials and construction will conform to Texas Department of Transportation (TxDOT) Specification 5003. Furnish materials in accordance with approved TxDOT Material Producer List). This item will be measured by the square foot of surface area and include all necessary materials, equipment and labor to complete per plans.
 - F. **Transportation Information Holder.** Furnish and install transportation information holders as shown on the plans and details. This Item will include all materials necessary to construct an information display board as shown on the plans, including, but not limited to, one (1) aluminum transportation information holder with tamper resistant stainless steel attachment hardware (one-sided) with powder coated finish (display size 11" x 22", overall size 12" x 23") and one (1) impact resistant polycarbonate lens. Information holder will conform to Bunting

Tabloid Series (BGH_11-22) or equivalent. All construction methods will be consistent with the installation instructions specified by the manufacturer and details provided in the plans.

Holders will be measured by each display board complete in place and will include all necessary attachment hardware to install the holder onto the stop light pole.

- G. Blade Sign.** Blade signs will be measured for separately per the requirements of TxDOT Specification Item 636 "Aluminum Signs" and will include all necessary attachment hardware to install the sign onto the stop light pole.
 - H. Sun Metro Logo Panel.** Furnish and Install the Blockout and Sun Metro Logo Panel located at the stop locations as shown in construction plans and details. Logo Blockout shall be stabilized screening material level and compact material to 85% as per ASTM D1557. The Sun Metro Standard Logo Panel shall be Bomanite Artistic Concrete or equal and shall be approved by the Owner or Owner's Representative. Install Logo panel per manufacturer's recommendation and shall be ADA/TAS compliant. Panels shall be measured by each panel complete in place.
 - I. Waste Receptacles.** Furnish and Install 32 gallon flare door waste receptacles at stop locations as field located by the Owner or Owner's Representative. Waste receptacles shall be grey in color and shall conform to the performance and specification requirements of (<http://www.wabashvalley.com/>) Model # FR500P, #FR500R, or approved equal. This item will be measured by each waste receptacle assembly complete in place. All construction methods will be consistent with the installation instructions specified by the manufacturer.
- 3. Equipment and Construction.** All equipment and construction activities required to perform the work described in this section and shown on the drawings will be executed in accordance with the requirements of the Texas Department of Transportation Standard Specifications for Highways, Streets, and Bridges or in accordance with City of El Paso requirements.
- 4. Payment.** The work and materials furnished in accordance with this Item will be measured as specified under "Materials and Measurement" and will be paid for at the unit price bid for the items noted below:
- a. Shelters – (EA)
 - b. Benches – (EA)
 - c. Leaning Rail – (LF)
 - d. Barrier Rail/ Handrail will be paid for under TxDOT Item 450 – Rail (Handrail) (TY A) (LF). See TxDOT Item 450 "Railing" for further specification information.
 - e. Detectable Warning Surface (Cast-in-Place) – (SF)
 - f. Furnish and Install Transportation Information Holder – (EA)
 - g. Blade Signs will be paid for under TxDOT Item 636 – Aluminum Signs (TY A) – (SF). See TxDOT Item 636 "Aluminum Signs" for further specification information.
 - h. Sun Metro Logo Panel – (EA)
 - i. Waste Receptacles – (EA)

SPECIAL SPECIFICATION

EP-TRACK REMOVAL

Removal of Existing Streetcar Track

1. **Description.** Break, remove, haul, and salvage or dispose of existing streetcar tracks encountered during construction that are buried under existing pavement. Locations shown on plans are based on historic and field observations and represent all historical locations where tracks may have existed. It is known that a significant amount of the existing tracks have already been removed.
2. **Construction.** Removal of existing streetcar tracks shall be conducted in a neat manner. Accept ownership and properly dispose of broken tracks in accordance with federal, state, and local regulations. Special care will be exercised to avoid damage to existing buried streetcar track that is to remain in place beyond the construction limits.
3. **Measurement.** This item will be measured by linear feet of existing track removed. Engineer's quantity measured is not based on the total linework shown on the plans, but general investigations of street reconstruction areas where historic streetcar tracks may have existed. If the quantity measured varies by more than 25% from the plan quantity, an adjustment may be made to the quantity of authorized work done for payment purposes.
4. **Payment.** The work performed and materials furnished in accordance with this Item will be paid for at the unit price bid for "Historic Streetcar Track Removal". This price will be full compensation for furnishing, preparing, hauling, and installing materials; and for labor, tools, equipment, hardware and incidentals necessary to complete the work.

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SPECIAL SPECIFICATION

EP-ARM

Banner Arm Assembly

1. **Description.** Provide and mount single configuration banner arm assembly for the El Paso Streetcar Project in El Paso, Texas, as shown on the plans.
2. **Materials.** Furnish all materials necessary to construct a proposed single configuration banner arm assembly as shown on the plans, including, but not limited to, two (2) round banner decorative finial assembly arms and two (2) clamp bands. Banner arm assemblies shall be evergreen (RAL 6005) in color and shall conform to the performance and specification requirements of BANNERARMS.COM Type Morsa or approved equivalent. All construction methods shall be consistent with the installation instructions specified by the manufacturer and details provided in the plans.
3. **Measurement.** This Item will be measured by each banner arm assembly (equivalent to one pair of banner arms) complete in place.
4. **Payment.** The work performed and materials furnished in accordance with this Item will be paid for at the unit price bid for "Banner Arm Assembly (2 Arms)". This price will be full compensation for furnishing, preparing, hauling, and installing materials; and for labor, tools, equipment, hardware and incidentals necessary to complete the work.

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06/19/2015

Pun Bhakta, P.E.

SPECIAL SPECIFICATION

EP-IRON FENCE

Installation of Wrought Iron Fence
and Gates at TPSS

1. **Description.** Furnish and Install a wrought iron perimeter fence at TPSS locations for the El Paso Streetcar Project at the locations identified on the plans.
2. **Materials and Construction.** Furnish and match all materials and construction in accordance to the aesthetic and performance characteristics of the wrought iron fence listed in the Maintenance and Storage Facility plans and specifications volume.
3. **Measurement.** This Item will be measured by linear foot of fence complete in place and includes fence gates as required by the Owner.
4. **Payment.** The work performed and the materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "TPSS Perimeter Fence". These prices will be full compensation for furnishing, preparing, hauling, and installing materials; and for labor, tools, equipment, hardware and incidentals necessary to complete the work.

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SPECIAL SPECIFICATION**EP-LUMINAIRE****Special Illumination****1. Description.** Furnish and install the following items to provide illumination throughout the project:

Provide the following at streetcar stops where the light poles are not joint use Overhead Contact System (OCS) poles:

- Decorative light pole with 2 luminaire extension arms
- LED light fixtures
 - Standard Type
 - Dark Sky Compliant Type

Provide the following at joint use OCS poles used at streetcar stops and located throughout the project:

- LED light fixtures
 - Standard Type
 - Dark Sky Compliant Type
- Arms for attaching light fixtures and decorative OCS poles are identified and paid for separately as indicated elsewhere in the project documents.

The LED Luminaire shall be designed for ease of maintenance and shall incorporate a plug-in electrical module for connection of the LED light source to the service voltage. The acorn shaped luminaire shall contain a precision optical system that maximizes post spacing while maintaining uniform illumination.

2. Materials. Special materials for fixtures shall be as follows:

Optical System (Standard Type Only). The optical system shall consist of a precisely molded thermal resistant glass refractor and top reflector mounted within the decorative aluminum banding. The top refractor shall redirect over 50% of the upward light into the controlling refractor while allowing a soft uplight component to define the acorn shape of the luminaire. The lower reflector shall use precisely molded prisms to maximize pole spacing. Asymmetric and symmetric light distributions shall be available.

Luminaire Housing. The cast aluminum luminaire housing provides an enclosure for the plug-in electrical module. Stainless steel fasteners shall secure all internal components including the prismatic refractor. The slip fitter shall accept a 3" by 2-7/8" to 3-1/8" O.D. tenon.

Luminaire Housing/Door. The luminaire door shall open with minimum use of tools and be retained on a hinge.

Electrical module. The electrical components shall be mounted on an aluminum plate that is removable with minimum use of tools. A matching multi-conductor plug shall connect to the receptacle in the luminaire housing to complete the wiring.

Finish. The luminaire shall be finished with polyester power paint to ensure maximum durability. The luminaire shall be suitable for outdoor service.

- LED Driver – 100 watts (525mA)
- Color temperature – 4K (4000 Series CCT)
- Voltage – Auto-sensing voltage (347 thru 480VAC)
- Housing Color – Green
- Optics – Asymmetric
- Trim Color – Gold
- Decorative Trim – Band, Medallions & Spike Finial

Wattage. Actual wattage may differ by +10%/-10% at operating temperature.

Post. The lighting post shall consist of a one-piece fluted tapered pole, pole top tenon, anchor bolts and base plate. The post shall be welded to the square steel base plate. Refer to the part indicated below for additional material and performance characteristics.

Aesthetic and Performance Characteristics. The streetcar stop light pole, luminaire arms, and fixtures shall follow the aesthetic and performance characteristics of the standard City of El Paso decorative style as indicated on the plans and the following product:

LED Light Fixture (Standard): Holophane WAUE1004KAHN3G2 or approved equivalent

LED Light Fixture (Dark Sky Compliant): Holophane WAUE1004KAHN3G2 with Option “F” (Full Cover) or approved equivalent

Decorative Light Pole with two luminaire extension arms: Holophane LB33-4-1/2T DECO EXTENSION ANDG (MOD) - FL210-700A180-P9-FP-HH-LAB - AB-27-4 - AN24CSBCADG or equivalent

3. Measurement and Payment.

LED Fixtures. This Item will be measured by each at the unit price bid for “LED Fixture (Standard)” and “LED Fixture (Dark Sky Compliant)”. This price will be full compensation for furnishing all materials, equipment, labor, and incidentals necessary to complete the work specified in the plans.

Scenario A and B. (Locations other than Streetcar Stops). For light fixtures on Joint-Use OCS poles at locations other than streetcar stops, the conductor within the OCS pole will be incidental to the LED fixture. Junction boxes at these locations will be quantified based on 1 junction box per location and paid for separately under TxDOT Item 624 "Ground Boxes". Proposed conductor and conduit extensions (or tie-ins with existing conductors or conduit) from the Joint-Use OCS pole to the proposed junction box from the existing light will be paid for separately in accordance with TxDOT Item 618 "Conduit" and TxDOT Item 620 "Electrical Conductors". This price will be full compensation for furnishing all materials, equipment, labor, and incidentals necessary to complete the work specified in the plans.

Scenario C (Streetcar Stop Locations Only). For fixtures on Joint Use OCS poles at streetcar stop locations and standalone decorative light poles at streetcar stop locations, the conductor within the pole will be subsidiary to the LED Fixture. Proposed conductor and conduit from the Joint-Use OCS pole or standalone decorative light poles to the proposed junction box from the existing light will be quantified as indicated in the Electrical Conduit Runs Plans and paid for separately in accordance with TxDOT Item 618 "Conduit" and TxDOT Item 620 "Electrical Conductors". The junction boxes will be paid separately (under TxDOT Item 624 "Ground Boxes") and quantified as indicated in the Electrical Conduit Runs Plans.

Decorative Pole. This item will be measured by each at the unit price bid for "City of El Paso Style Decorative Light Pole" and shall include the 2 luminaire attachment arms and aesthetic caps. This price will be full compensation for furnishing all materials, equipment, labor, and incidentals necessary to complete the work specified in the plans. Note that this clause applies to standalone light poles at streetcar stops and not Joint-Use OCS poles. Refer to OCS plans and specifications for details related to Decorative OCS poles.

SPECIAL SPECIFICATION

EP-FENCE GROUND

Fence Grounding

1. **Description.** This Item shall govern grounding of the decorative railing/fence on the Stanton bridge over IH-10 as indicated on the fence grounding details in the plans.
2. **Materials.** Provide the following materials or approved equivalent:

Grounding Material	Part Number	Qty.
Copper ground rod 5/8" x 8 feet		2
#2 bare copper (Strained) conductor [fence to ground rod]	#2 AWG	20 feet
Harger 1/4" two hole insulated bonding jumper kit	GJ67G102A1/4KIT	1 kit
Burndy bonding connector	BCS-23 (Mold # B-2781)	2

3. **Construction.** Construct the materials above in accordance with the plans.
4. **Measurement.** Measure as a lump sum, complete in place as shown on the plans.

Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid at the unit price bid for "Fence Grounding." This price is full compensation for furnishing, preparing, hauling, and installing materials; and for labor, tools, equipment, and incidentals necessary to complete the work.

URS Corporation
TBPE Firm Registration No. F-3162



URS Corporation
TBPE Firm Registration No. F-3162

SPECIAL SPECIFICATION

EP-GROUT



6/7/2013

Pressure Grouting beneath Center Bent Footings of Stanton Street Bridge

- 1. Description.** This Item shall include Pressure Grout treatment and improvement of the bearing soils beneath three (3) spread footings supporting the center bent of the Stanton Street Bridge. The Pressure Grout treatment is also referred to as "Condition Grouting" which consists of a process of injecting neat cement into the subsurface under relatively low pressures so that surrounding slabs (pavements) and bridge structural components are not heaved.

Project site conditions include areas of restricted access and low head room. The pressure grouting work will be performed under an existing bridge, at the center bent, on Interstate Highway IH-10. Site conditions include an existing vertical traffic barrier and concrete pavements. Subsurface conditions include gravel, sand and clay mixtures, and include localized zones of high density soils. The work will likely include restricted work hours and work space.

The Pressure Grout zone will include improvements to bearing soils generally ten (10) feet below the existing footing bearing elevation. According to the original design plans (circa 1967), the bottom of footing elevation is estimated to be 5 feet below the existing pavement surface.

The location and depth of each grout hole shall be as indicated on the drawings (Work Plan). Only qualified grouting contractors, with at least 5 years of demonstrated experience with similar grouting programs, shall be considered.

- 2. Submittals:** Drawings, specifications, and data covering the proposed materials shall be submitted in accordance with the Submittals Procedures section.

The Contractor shall submit a list of drilling and grouting equipment and procedures to be used in accordance with the Submittals Procedures section. The Contractor shall submit in detail their proposed grout injection method, equipment calibrations, report forms, and uplift monitoring plan at least 30 days prior to the start of grouting operations.

The Contractor will submit a proposed grout mix design including quantity and specification of components, and demonstrated compressive strength results of 3,000 psi at 28 days. Mix design report shall include data less than 1 year old, and include at least 15 compressive strength test results (per ACI 318).

- 3. Materials.** Where the use of the following materials is specified herein, such materials shall be in accordance with these requirements:

- a. Cement - ASTM C150 Type I/II.
- b. Water - Clean and free from mud, oil, salts, organic matter, or other deleterious substances.
- c. Bentonite - Bentonite shall be sodium (Na) cation, powdered montmorillonite.
- d. Admixtures - Admixtures may consist of accelerators, retarders, water reducers, aluminum powder, and/or fluidifiers

The Contractor shall furnish all equipment for accurately measuring and thoroughly mixing the grout ingredients. The Contractor shall furnish tanks of sufficient capacity, suitable water meters graduated in cubic feet and tenths, air compressors of suitable capacity, water pumps, pressure gauges, valves, pressure hose supply lines, pipe fittings, and small tools as may be necessary to provide a continuous supply of grout and accurate pressure control. Equipment should include:

- a. Injection Pipes: $\frac{3}{4}$ to 1 inch diameter, open pipe with a sacrificial steel driving point. Alternatively, injection holes may be predrilled with rotary methods.
- c. Low Head Space Injection Equipment: Due to work under existing bridge, a low head space operation will need to be designed for the grout injection operation.
- d. Concrete Coring Equipment: Concrete coring through the existing pavement, vertical barrier structure, and existing footing will be required prior to grouting. The vertical barrier structure may or may not be removed prior to grouting. The existing footing is reportedly 2 feet thick and contains reinforcing steel. Cored holes through the concrete footing shall be 4 inches in diameter or less.
- e. Grout Pump: The pump used for grouting shall be field calibrated prior to initial grouting. Field calibration will consist of pumping accepted grout mix design into a container of known volume (i.e. 55-gallon drum) and measure number of strokes. The field calibration shall be observed by a representative of the Geotechnical Engineer.
- f. Pressure Gauges: All pressure gauges should include current calibrations (within 1 year at the time of service) and records shall be provided to the Geotechnical Engineer or representative prior to field use.

- 4. Construction.** A representative of the Geotechnical Engineer shall be present during grouting operations to confirm/verify grout depths and grout takes. The Contractor should notify the Geotechnical Engineer at least 48 hours prior to commencement of the work.

The Contractor shall be prepared to perform grouting operations through the existing vertical barrier. This may require coring or partial removal of slabs and barriers, and advancing through infill material (possible gravel).

Contractor shall be responsible for any specified Traffic Control Plan and nighttime work, if or as needed.

- a. Drilling - The location and depth shall be as indicated on the drawings (Work Plan).

The requirements as to location, depth, and spacing are subject to revision during the drilling, testing, and grouting. It is expected that the required depth of holes will not exceed 15 feet below the pavement surface, or 20 feet below the top of vertical barrier. Grout holes shall be drilled sufficiently plumb and straight to allow grouting equipment to pass the full length of the hole without obstruction. The drilling method shall support the soil materials prior to grouting.

The top of the grout hole shall be located within 1 foot of their positions indicated on the drawings.

The use of rod dope, grease, or other lubricants on the drill rods or in the borings will not be permitted, except that an approved neutral liquid soap may be added to the drill water. Drilling equipment and techniques shall minimize oversized or caved holes.

All drilling shall be performed with clear water or clear water/compressed air combinations of sufficient pressure and flow to guarantee good washing and cutting removal.

Holes shall be capped after drilling and cleaning. Any hole or pipe that becomes clogged before grouting is completed shall be reopened by the Contractor.

The Contractor shall grout the holes using the pattern on the drawing (Work Plan). A total of 30 grout holes has been requested on the Work Plan, but may be higher if measured grout takes are substantially less than anticipated. Not more than 10 additional grout holes would be added if overall grout take is relatively low, at the discretion of the Geotechnical Engineer.

- b. Grouting Equipment - All pressure grouting operations shall be performed in the presence of the Owner or its duly authorized representative.
- c. Grouting Procedure - The grouting procedure method shall provide improvement to the soil using the fracture grouting method. The soil targeted for improvement is from 5 to 20 feet below existing grade. Acceptable injection methods include but are not limited to packers, injection pipes, and tube manchette. In addition, the contractor should monitor and limit uplift as specified. It is important that the existing structure should not be subjected to uplift.

The required injection pressures for grouting shall be based on conditions encountered. The initial grout pressure may be increased to facilitate the opening of the grouting port, but it is envisioned that grouting pressures should immediately be reduced to prevent uplift or heave. During grouting the maximum gauge pressure should not exceed 3 psi per foot of vertical depth of hole to the middle of the section being tested or grouted unless directed by the engineer. All pressures shall be measured at the top of the drill holes.

Regulation, measurement, and supervision of pressure shall be carried out continuously. Pressure increases shall be controlled and the pressure shall not exceed the allowable value. The Contractor shall maintain the pressure within such limits as will ensure that uplift of the structure does not occur. Under no conditions shall the pressure or rate of pumping be increased suddenly. Grouting shall cease immediately if sudden grout leak or loss of pressure occurs, or if uplift occurs.

When grouting is completed, the grout holes shall be backfilled with grout to the top of concrete.

- d. Grout Placement - Only grouts consisting of a mixture of Portland cement, prehydrated bentonite, admixtures and water shall be used. Only pre-approved grout mix designs are allowed. The contractor may choose to submit alternative mix designs in anticipation of variable site conditions.

Grout mix design shall have with a 28-day compressive strength of 3,000 psi. Trial batches and compressive strength test (ASTM C109) reports are required prior to grouting.

All grout shall be placed within 2 hours of mixing. Wasted grout is not measured or paid for by the owner.

Volume of grout injected shall be measured in cubic feet. A field calibration of the proposed group pump will be required prior to grout production.

- f. Monitoring Points - Monitoring points shall be established on the center bent columns and pavement surface. A minimum of 6 points (2 points per column) are required for the bridge columns, and 6 points on the pavement surface. The monitoring plan shall be submitted to the Geotechnical Engineer for review and approval.

Elevations shall be taken before starting the grouting and at least daily unless more frequent readings are required to effectively monitor the ground. The measurements shall be able to detect heaving on the order of 1/8 inch.

In the event of concrete slab upheaval of 1/8 inch, the grouting pressure shall be lowered or grouting operations ceased. The grout mix, pressures and the grouting methods must be reviewed and adjusted in consultation with the geotechnical engineer before resumption of work. Maximum allowable heave of the slab/footing is ½ inch.

- e. Cleanup - Upon completing all drilling and grouting in an area, all casings, scrap, trash, waste materials, and debris resulting from work shall be removed from the site and disposed of properly.

- 5. **Reporting.** The Contractor shall furnish copies of the following weekly reports to the Owner. Copies of proposed forms, drilling logs, and grouting logs to be used shall be submitted to the Owner for review and approval prior to the start of the work.

The Contractor shall keep current records on forms approved by the Owner at the site of all information required to prepare the reports. The Contractor's records shall be available to the Owner at all times during the progress of the work. One copy of each daily record shall be furnished to the Owner each day. The Contractor's reporting should be in agreement with records obtained by the field representative of the Geotechnical Engineer.

- a. Drilling Report - The drilling report shall contain the following information:
 - 1) Date and drill rig identification.
 - 2) Hole identification and diameter.
 - 3) Time drilling was started and completed.
 - 4) Log of drill cuttings indicating color and lithology of rock based on visual observations, elevations of changes in lithology, location and extent of cavities, soft spots, presence of ground water, locations of drilling fluid losses or gains (i.e., air), and pressures at which drill hole was washed, if required.
 - 5) Observations and incidents during the course of drilling, flushing, and pressure washing including connections to other holes and/or surface.
 - 6) Total depth.
- b. Batching Report. The batching report shall contain the following information:
 - 1) Date
 - 2) Shift
 - 3) Weather
 - 4) Batch plant number
 - 5) Mix design
 - 6) Time grout batched and pumped
 - 7) Constituent volume -water, cement, and admixtures (if any)
 - 8) Total volume
 - 9) Holes grout pumped to
 - 10) Remarks
- c. Grouting Report. A grouting report shall be prepared for each grouted hole. The grouting report shall contain the following information:
 - 1) The number of the grout hole.
 - 2) The dates and time of the start and finish of the operation.
 - 3) The position of the packer or injection pipe. The grout proportioning, the injection pressure, the injection flow, and the time at which each of these parameters was varied; also, the quantities injected between the variations of any of these parameters.
 - 4) The total grout take of the hole, in sacks of cement, and as strokes per foot of depth.
 - 5) Observations and incidents during the course of grouting including
 - 6) Connections to other holes and/or surface.

d. Monitoring Report. Provide data for all heave monitoring points.

- 6. Measurement and Payment.** Payment will be made for all work satisfactorily performed and materials furnished in accordance with this Special Specification and contract drawings which includes but not limited to mobilization and demobilization, submittal and reports, furnishing storing and transporting all materials, plants and equipment, coring, drilling, mixing grouts and injection of pressure grout up to an injected volume of 720 cubic feet, installation of monitoring points and monitoring of heave as one lump sum price. No measurement will be made for the work except for the injected volume of grout in cubic feet.

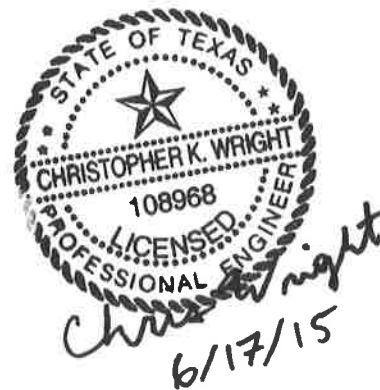
Grout volume in excess of 720 cubic feet (cubic feet) will be paid for at an unit price per cubic feet.

SPECIAL SPECIFICATION

EP-SWP

SPECIAL GRATE INLET PROTECTION

1. **Description.** Furnish and install a grate inlet protection for the El Paso Streetcar Project in El Paso, Texas, as shown on the plans.
2. **Materials.** Furnish all materials necessary to construct a grate inlet protection as shown on the plans, including, but not limited to a wooden frame and filter fabric. The wooden frame shall be dropped below the grate into the inlet box to adequately secure filter fabric over the discharge pipe opening. The filter fabric material should be consistent with that used for silt / sediment fencing approved by the City of El Paso. The filter fabric material should also meet the minimum specifications outlined by TxDOT for the standard inlet protection. All construction methods shall be consistent with the installation instructions specified by the manufacturer and details provided in the plans.
3. **Measurement.** This Item will be measured by the each inlet protection complete in place.
4. **Payment.** The work performed and materials furnished in accordance with this Item will be paid for at the unit price bid for "Special Grate Inlet Protection".



URS Corporation
TBPE Firm Registration No. F-3162

SPECIAL SPECIFICATION
EP-LAND
Miscellaneous Landscape Elements



6/17/15

1. **Description.** This Item shall govern for supplying and installation of Tree Grates and Meter Assemblies, as shown on the plans and this specification.
2. **Materials and Construction.**
 - (1) Grates - Furnish and Install Tree Grates as shown on the landscaping plans. Utilize Tree Grate models indicated in plans or approved equivalent.
 - (2) Water Meter Assemblies - Furnish and Install Water Meter Assemblies as shown on the landscaping plans and in standard details of water replacement plans. Apply for new meter permit, and provide all fees and associated filing materials.
3. **Measurement.** Measure Tree grates as each model, complete in place as shown on the plans. Measure Water Meter Assemblies as each, complete in place as shown on the plans.
4. **Payment.** The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid at the unit price bid for "Furnish and Install Tree Grate", and "Furnish and Install Water Meter Assembly". This price is full compensation for furnishing, preparing, hauling, and installing materials; for excavation and backfill; and for labor, tools, equipment, and incidentals necessary to complete the work.

Special Specification EP-TSP

EMERGENCY PREEMPTION TRAFFIC SIGNAL PRIORITY CONTROL SYSTEM INSTALLATION



1. DESCRIPTION

This Item governs the installation of emergency vehicle traffic signal priority control system in field location(s) as shown on the plans and as detailed in the Special Specifications. This system shall enable designated vehicles to remotely cause the traffic signal controller to advance to and/or hold a desired traffic signal display by using existing controller functions.

2. MATERIALS

Use material removed under item 680 as shown on the plans. Install appropriate surge protectors in the cabinet for the Emergency Preemption Phase Selector and Emergency Preemption Detector.

3. FUNCTIONAL REQUIREMENTS

The Emergency Preemption Detector shall transform the optical energy detected from an approaching, vehicle mounted emitter to an electrical signal. The electrical signal shall be transmitted along an Emergency Preemption Detector Cable to the Emergency Preemption Phase Selector for processing.

The Emergency Preemption Detectors shall permit a direct, unobstructed line-of-sight to vehicle approaches.

The Emergency Preemption Detector has a cone of detection of not more than 13 degrees. The Emergency Preemption Detector and/or Emergency Preemption Phase Selector shall not sense a pre-emption signal from an emitter outside this cone.

Install the Emergency Preemption Detector to have a reception range of 1000 ft. or as directed by the Engineer.

4. MECHANICAL COMPONENTS

Use stainless steel for all external screws, nuts, and locking washers; do not use any self-tapping screws unless approved by the Engineer.

Protect all materials used in construction from fungus growth and moisture deterioration.

All equipment shall be installed and wired in a neat and orderly manner in conformance with the manufacturers' instructions.

Emergency Preemption Detector Cables shall be installed continuous with no splices between the Emergency Preemption Detector and the cabinet.

Emergency Preemption Detector locations shown on the plan are for illustration purposes only. Exact location shall be determined by the manufacturer or the designated representative or the site engineer for the best possible line of sight.

5. TESTING

Perform testing in accordance with Article 2, Special Specification, "Testing, Training, Documentation, Final Acceptance, and Warranty". Testing

All adjustments such as Emergency Preemption Phase Selector range, sensitivity, detector placement, shall be made at the intersection, by the contractor so that the optical pre-emption operates correctly with other major manufacturers' equipment currently owned by the agencies in the project area.

6. MEASUREMENT

This Item will be measured as each TSP detector component installed, made fully operational, and tested in accordance with this special specification or as directed by the Engineer.

7. 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 "TSP SYSTEM (INSTALLATION ONLY)". This price is full compensation for placing, testing all materials and equipment, and for all tools, labor, and incidentals.

Walter P. Moore and Associates, Inc.
TBPE Firm Registration No. 1856



Luis Cardenas, P.E.
6/17/15

Special Provision to Item 680

Highway Traffic Signals



Item 680, "Highway Traffic Signals" 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 or Section being amended, supplemented, or voided (use main body style with bolded title and regular, unbolded text for opening statements.)

Article 2. Materials is supplemented by the following:

Use salvaged material removed as described in this specification and as shown on the plans. Provide new material for "Traffic Signal Arm Assembly" as stated in this specification and as directed by the Engineer.

Article 3. Construction is supplemented by the following:

Traffic signals must remain in operation during construction until their removal as directed. The Contractor will not be responsible for maintenance of the signals until traffic signal operations is affected by construction.

Remove existing arm assemblies, street name signs, traffic signal heads, vehicle detection system, traffic signal priority system, pedestrian signal heads, pedestrian push button, pedestrian signs, street name signs, and others accessories as shown on layouts.

Traffic Signal Head consists of an assembly of one or more signal sections together with the associated signal housing including back plates and louvers when required, attached at a common location on a support.

Remove all existing cable regardless of type or number from existing pole and or conduit system. Before removal of existing equipment, produce a list of equipment to be removed. The list must show existing condition of items to be removed. The list must be provided to the Engineer and EPDOT representative for approval prior to removal. Assume full responsibility of damaged electronic equipment, signs or cables that were functioning properly before the removal. Any damaged equipment must be replaced by the Contractor to an equal or better condition at no cost to the City or the State. Store removed equipment in a secure and safe place.

Removed equipment will be used in places shown on the layouts. The equipment not used must be returned to EPDOT at the location directed by the Engineer.

Article 3. Measurement is voided and replaced by the following:

Installation. This item will be measured as each arm assemblies, traffic signal mast-arm installed, street name signs installed, traffic signal heads, pedestrian signal heads, pedestrian push button and pedestrian signs installed, integrated and made fully functional. A traffic signal is a signalized intersection controlled by a single traffic signal controller.

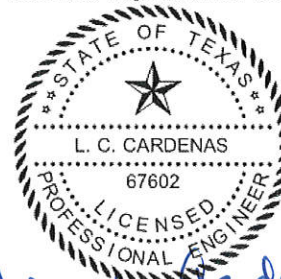
Removal. This Item will be measured as each arm assembly, mast-arm assembly, street name signs, traffic signal heads, vehicle detection system, traffic signal priority system, pedestrian signal heads, pedestrian push button and pedestrian signs removed and stored.

Article 4. Payment is supplemented by the following:

Installation. 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 "Installation of Traffic Signal Arm Assembly" of the size specified, "Re-installation of Street Name Sign", "Re-installation of Traffic Signal Heads", "Re-installation of Pedestrian Signal Heads", "Re-installation of Pedestrian Push Buttons", "Install of Signal Head Assembly" and Re-installation of Pedestrian Signs". This price is full compensation of materials, labor, tools, accessories, testing, and incidentals.

Removal. 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 "Removal of Arm Assembly", "Removal of Mast Arm", "Removal of Street Name Sign", "Removal of Traffic Signal Heads", "Removal of Vehicle Detection System", "Removal of Traffic Signal Priority System", "Removal of Pedestrian Signal Heads", "Removal of Pedestrian Push Buttons", "Removal of Ped Pole Assembly" and Removal of Signs". This price is full compensation of removal of associated cabling and related hardware, materials, labor, tools, accessories, documentation, and incidentals.

Walter P. Moore and Associates, Inc.
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Louder Cardenas, P.E.
6/17/15

Special Provision to Special Specification 6002

Video Imaging Vehicle Detection System



Item 6002, "Video Imaging Vehicle Detection System" 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 1. Description is supplemented by the following:

Use salvaged material removed under item 680 and as shown on the plans.

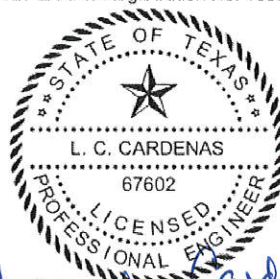
Article 13. Measurement. The first paragraph is voided and replaced by the following:

The VIVDS will be measured as each VIVD detector camera and cable components installed, made fully operational, and tested in accordance with this special specification or as directed by the Engineer.

Article 14. Payment. The first paragraph is voided and replaced by the following:

The work performed, materials, and all accompanying software furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "VIVDS Processor System," "VIVDS Camera Assembly," "VIVDS Camera (Installation Only)," "VIVDS Central Control," "VIVDS Set-up System," "VIVDS Temporary," "VIVDS Communication Cable (Coaxial)," "VIVDS Communication Cable (Fiber Optic)," and "VIVDS Video Recording." These prices are full compensation for furnishing, placing, and testing all materials and equipment, and for all tools, labor, equipment, hardware, operational software packages, supplies, support, personnel training, shop drawings, documentation, and incidentals. A 3-conductor power cable must be included with the communication cable.

Walter P. Moore and Associates, Inc.
TBPE Firm Registration No. 1856



Luis Cardenas, P.E.
6/17/15

SPECIAL SPECIFICATION

EP-WWWR

Water & Wastewater Relocation

- 1. Description.** Replace and relocate the water and wastewater lines in conjunction with the El Paso Streetcar Project in El Paso, Texas, as shown on the plans and the attached specifications.
- 2. Materials.** All materials furnished and all construction methods utilized shall be in accordance with the plans, details, and attached specifications.
- 3. Measurement.** This Item will be measured as indicated in the attached specifications.
- 4. Payment.** The work performed and materials furnished in accordance with this Item and measured as provided for under "Measurement" will be paid at the unit price bid as indicated in the bid form.

Attached:

- **TxDOT El Paso District Special Specification ITEM 5878: WATER AND SANITARY SEWER SYSTEMS**
- **TxDOT El Paso District Special Provision to ITEM 5878-002: WATER AND SANITARY SEWER SYSTEMS**

SPECIAL SPECIFICATION
5878
WATER AND SANITARY SEWER SYSTEMS

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I. WATER MAINS

- 1. Description.** This Item shall govern for all materials and work necessary for the installation of all water mains as shown on the plans.
- 2. Materials.**
 - A. Polyvinyl Chloride (PVC) Pressure Pipe.**
 - 1. Scope.** These specifications cover the requirements for polyvinyl chloride (PVC) pressure plastic pipe materials and installation for potable water use. These specifications shall apply to PVC pipe in sizes 4-inch through 16-inch diameters.
 - 2. Quality Assurance.** All PVC pipe shall be color-coded blue to provide positive identification and prevent accidental damage to or interruption of the water

facilities. Pipe shall conform to American National Standards Institute/National Sanitation Foundation (ANSI/NSF) Standard 61 “Drinking Water System Components - Health Effects” and be certified by and organization accredited by

ANSI. Such compliance shall be evidenced by an affidavit from the manufacturer or vendor. If the pipe does not presently conform to this standard, information from the manufacturer regarding action being taken to comply with this standard must be submitted.

Only pipe manufactured in the United States of America will be accepted.

Pipe shall be suitable for use in the conveyance of water for human consumption. Each piece of pipe shall be marked with two seals of the testing agency that certified the pipe material as being suitable for potable water use.

3. **Submittals.** The CONTRACTOR shall be responsible for furnishing all necessary shop drawings, certificates, etc. for review and acceptance to the ENGINEER. A certification from the manufacturer shall be furnished to the ENGINEER attesting compliance with appropriate ASTM Standards and ANSI/NSF Standard 61. Such compliance shall be evidenced by an affidavit from the manufacturer or vendor. If the pipe does not presently conform to this standard, information from the manufacturer regarding action being taken to comply with this standard must be submitted. Failure to provide this information may result in rejection of pipeline material.

Submit documentation on pipe products, fittings, and related materials as may be required by the Contract Documents or the ENGINEER. Review all submittals prior to submission. Submit it in a timely manner so as not to delay the project. Allow sufficient time for ENGINEER’s review and resubmission, if necessary. Include certifications from manufacturer that the product complies with appropriate ASTM standards.

4. **Standards.** PVC Pressure Pipe shall comply with the applicable requirements of the following items listed below. In case of conflict between the requirements of these Specifications and those of the listed documents, the requirements of this Section shall prevail.

ANSI/NSF 61	Drinking Water System Components - Health Effects
ASTM F-477	Specifications for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM D-1784	Specifications for Rigid Polyvinyl Chloride (PVC) Compounds and Chlorinated Polyvinyl Chloride (CPVC) Compounds
ASTM D-2241	Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR-Series)
ASTM D-2774	Recommended Practice for Underground Installation of Thermoplastic Pressure Piping

AWWA C-651	Standard for Disinfecting Water Mains
AWWA C-900	Standard for Polyvinyl Chloride (PVC) Pressure Pipe, 4-inch through 12-inches, for Water Distribution
AWWA C-905	Standard for Polyvinyl Chloride (PVC) Water Transmission Pipe, Nominal Diameters 14-inch through 36-Inches
AWWA M-23	Manual: PVC Pipe - Design and Installation
UNI-BELL-3	Polyvinyl Chloride (PVC) Pressure Pipe (Complying with AWWA Standard C-900)
UNI-BELL-11	Polyvinyl Chloride (PVC) Water Transmission Pipe Nominal Diameters 14-36 inches
Texas Commission on Environmental Quality, Chapter 290 - Public Drinking Water	

- 5. Delivery and Storage.** Pipe, fittings, and accessories shall be inspected upon delivery and during progress of the work. Any material found defective will be rejected by the ENGINEER, and shall be promptly removed from the site.

All pipe, fittings, and other accessories shall, unless otherwise directed, be unloaded at point of delivery, hauled to and distributed at the site of the work by the CONTRACTOR. In loading and unloading, materials shall be lifted by hoists or rolled on skidways to avoid shock or damage. Under no circumstances shall materials that have been dropped be incorporated in the work. Pipe handled on skidways shall not be skidded or rolled against pipe already on the ground.

PVC pipe shall not be stored outside exposed to prolonged periods of sunlight. Any discoloration of pipe due to such exposure is an indication of reduced pipe impact strength, and will be sufficient cause for rejection of the pipe. Any pipe rejected shall be removed from the job site.

- 6. Pipe Materials.** Pipe shall meet the requirements of AWWA C-900 for 4-inch through 12-inch sizes, and AWWA C-905 for 14-inch through 36-inch pipe. Pipe shall be Underwriters Laboratories (UL) approved. All PVC pressure pipe shall be furnished in cast iron pipe equivalent outside diameters and a standard laying length of 20-feet. Minimum pressure class shall be 235 psi (DR 18) for 4-inch through 12-inch diameters. Minimum pressure rating will be 200 psi (DR 21) for 14-inch through 16-inch pipe.
- 7. Joints.** Pipe joints shall be push-on, flexible elastomeric gasketed. The pipe length shall contain one bell-end or couple with a synthetic elastomeric gasket. Gaskets shall meet the requirements of ASTM F-477. The bell shall be an integral part of the pipe length and have the same strength and DR as the pipe. The spigot pipe end shall be beveled.

All pipe shall have dual insertion marks on the spigot indicating proper penetration when the joint is assembled and only one mark remains visible. The sockets and/or

spigot configurations for the fittings and couplings shall be compatible to the pipe. Socket configuration shall prevent improper installation of gasket and shall ensure that the gasket remains in place during joining operations.

8. **Fittings.** Pipe fittings shall be ductile iron, cement lined, in accordance with AWWA C-110 and these Specifications, Valves and Fittings. Pipe fittings shall be mechanical joint (MJ) unless otherwise specified.
9. **Provisions for Thrust.** For 12-inch diameter water mains and smaller, concrete thrust blocks or other approved thrust restraint method shall be installed at all fittings and valves per design plans and in accordance with these Specifications. If approved, thrust restraint devices may be installed in lieu of thrust blocks as per manufacturer's specifications.

For 16-inch diameter water mains and larger, thrust restraint devices must be installed at all fittings and valves per manufacturer's specifications and as shown on design plans. Concrete thrust blocks are not allowed unless approved by the ENGINEER.

Acceptable thrust restraint devices include EBAA Iron, Ford Uni-Flange, or approved equal.

NOTE: At connection of new water line to existing main, both concrete thrust blocking (per these Specifications) and thrust restraint devices must be used, regardless of main size.

Thrust restraint devices shall be used for a sufficient distance from each bend, tee, plug, or other fitting to resist thrust which will be developed at the test pressure of the pipe. For the purposes of thrust restraint, test pressure shall be 1.5 times the design working pressure indicated. Length of pipe with restrained joints to resist thrust forces shall be determined by pipe manufacturer.

10. **Pipe Trenching, Installation and Backfill.** Except as noted, Pipe Trenching, Installation and Backfill for PVC Pressure Pipe shall be in accordance with AWWA M-23, C-900, C-905, and conforming to "Excavation and Backfill for Structures" Item 400 and details shown on construction plans.

Trench Width. The minimum clear width of the trench should be 1-foot greater than the outside diameter of the pipe. The maximum clear width of the trench at a point 1-foot above the top of the pipe is equal to the pipe outside diameter plus 2-feet. If the maximum recommended trench width is exceeded or if the pipe is installed in a compacted embankment, then pipe embedment shall be compacted to a minimum point of 2-1/2 pipe diameters from the side of the pipe or to the trench walls.

Pipe Zone Embedment. Unless otherwise specified, PVC pressure pipe shall be embedded in Class II material as defined in "Excavation and Backfill for Structures", Item 400. Native material or imported material meeting or exceeding Class II requirements may be used. Class I material is acceptable at the discretion of the CONTRACTOR.

Installation. Plastic pressure pipe shall be installed in accordance with AWWA M 23 and C-900/C-905 and/or manufacturer's printed recommendations, whichever is applicable. Where a conflict arises with this specification, this specification shall control.

Care shall be taken to insert the pipe spigot to the correct reference mark per manufacturer's recommendation to prevent buckling or separation of the pipe joint. The second insertion mark shall be visible after installation and not be further than 3/4-inch from the leading edge of the pipe bell. The CONTRACTOR shall verify that the manufacturer's reference marks are correct per manufacturer's literature.

Under no circumstances should the pipe or accessories be dropped into the trench. When pipe laying is not in progress, open ends of installed pipe should be closed to prevent entrance of trench water, dirt, and foreign matter into the line.

Marking Tape. PVC pressure water pipe shall be marked by concurrently installing the appropriate marking tape for detection purposes. The detectable tape shall consist of a 5.0 mil inert polyethylene plastic material. It shall be high visibility blue with the standard warning and identification for potable water imprinted on the tape. The minimum width of detectable tape shall be 6-inches for all potable water lines. The burial depth shall be 36-inches, measured from finished grade. Detecting tape shall be manufactured by Empire, Lineguard, or approved equal.

Deflection. Maximum ring deflection (cross-sectional deflection) of installed PVC pressure pipe shall be 5 percent. Joint deflection (horizontal deflection) shall not exceed manufacturer's recommendations for the particular size pipe.

Corrosion Protection. As a precaution against corrosion, all flanges, bolts, nuts and other exposed metal surfaces underground shall be coated with Texaco, Koppers, or approved equal rustproof compound.

11. **Testing.** Disinfect and test the piping system as detailed in AWWA C-651 and in accordance with "Cleaning, Disinfection, and Testing of Water System".

B. Ductile Iron Pipe.

1. **Scope:** Furnish all labor, materials, equipment and incidentals required and install all ductile iron piping, as shown on the drawings and as specified herein.
2. **Quality Assurance:** Manufacturer shall have a minimum of ten years successful experience in designing and manufacturing DIP of the type specified. The entire pipeline shall be the product of one manufacturer. The manufacturer shall have a minimum of ten years successful experience in designing and manufacturing pipe joints of similar design, pipe diameter, and pressure class as those specified. Pipe shall conform to American National Standards Institute/National Sanitation Foundation (ANSI/NSF) Standard 61 "Drinking Water System Components - Health Effects" and be certified by and organization accredited by ANSI. Such compliance shall be evidenced by an affidavit from the manufacturer or vendor. If the pipe does not presently conform to this standard, information from the

manufacturer regarding action being taken to comply with this standard must be submitted.

- 3. Submittals:** Submit documentation on pipe products, fittings, and related materials as may be required by the Contract Documents or the ENGINEER. Review all submittals prior to submission. Submit in a timely manner so as not to delay the project. Allow sufficient time for ENGINEER's review and resubmission, if necessary. Include certifications from manufacturer that the Ductile Iron Pipe complies with appropriate AWWA Standards and ANSI/NSF Standard 61.

Such compliance shall be evidenced by an affidavit from the manufacturer or vendor. If the pipe does not presently conform to this standard, information from the manufacturer regarding action being taken to comply with this standard must be submitted.

If requested, copies of results of factory hydrostatic tests shall be provided.

- 4. Standards:** DIP shall comply with applicable requirements of the following items listed below. In case of conflict between the requirements of these Specifications and those of the listed documents, the requirements of this Section shall prevail.

ANSI/NSF 61	Drinking Water System Components - Health Effects
ASTM A-536	Specification for Ductile Iron Castings
AWWA C-104	Standard for Cement Mortar Lining for Ductile Iron Pipe and Fittings
AWWA C-105	Standard for Polyethylene Encasement for Ductile Iron Piping
AWWA C-110	Standard for Ductile Iron and Gray Iron Fittings
AWWA C-111	Standard for Rubber Gasket Joints for Ductile Iron Pipe and Fittings
AWWA C-150	Standard for Thickness Design of Ductile Iron Pipe
AWWA C-151	Standard for Ductile Iron Pipe
AWWA C-214	Tape Coating Systems for the Exterior of Steel Water Pipelines
AWWA C-600	Standard for Installation of Ductile Iron Water Mains & Appurtenances
AWWA C-651	Disinfecting Water Mains
Texas Commission on Environmental Quality, Chapter 290 - Public Drinking Water	

- 5. Pipe Materials:** Ductile iron pipe shall be manufactured in accordance with AWWA C-151. The minimum pressure class rating shall be 350 psi, unless otherwise specified. The Ductile Iron shall conform to ASTM Specification A-536 with physical properties of Grade 60-40-18. The pipe shall be designed for five (5) feet of cover or for the depths shown on the plans, whichever is greater.

Standard joint length shall be 18 or 20 feet and inside diameter shall be industry standard.

CONTRACTOR shall be responsible for all material furnished by him and shall replace, at his own expense, any material found to be defective in manufacture or damaged.

- 6. Joints:** Shall be in accordance with AWWA C-111, AWWA C-151. Standard joints for ductile iron pipe shall be push-on. Where indicated on the drawings, joints shall be mechanical or flanged. Flanged joints shall have pressure ratings

equal to or greater than adjacent pipe. Flange pattern shall match pattern of valve, fitting, or appurtenance to be attached.

7. **Fittings:** Shall be ductile iron in accordance with AWWA C-110 and Article V of these Specifications. Fittings shall be rated for a minimum working pressure of 250 psi, unless otherwise specified.
8. **Exterior Coating:** The manufacturer shall provide a standard asphaltic coating in accordance with AWWA C-151, unless otherwise specified. The finished coating shall be continuous, and smooth and strongly adherent to the pipe.

Polyethylene wrap shall be used on ductile iron for sizes 30-inches and smaller. The polyethylene wrap shall be applied in accordance with AWWA C-105/A21.5 except a minimum thickness of 30 mils shall be used.

Tape coating shall be used for pipe sizes 36-inch and larger where specified. The exterior of the pipe shall have a prefabricated cold-applied tape coating system conforming to the requirements of ANSI/AWWA C-214, except as noted herein. The surface shall be blast cleaned to achieve a surface preparation at least equal to that specified in SSPC SP6. The blast profile shall have an anchor pattern as specified by the tape manufacturer. The coating shall be held back from the end of the pipe the minimum distance recommended by the pipe manufacturer for the type of joint used. Tape wrap cut back shall be tapered. Nominal thickness shall be 80 mils.

9. **Interior Lining:** Ductile Iron Pipe and fittings shall have a cement mortar lining in accordance with AWWA C-104 and bituminous seal coat. Cement Type for lining shall be appropriate for pipe application. Lining thickness shall be as specified in AWWA C-104.
10. **Provisions for Thrust:** Where indicated and where required for thrust restraint, joints shall be restrained. Restrained joints shall be mechanically interlocking joints. Restrained joints shall be U.S. Pipe "TR Flex", American Cast Iron Pipe "Flex Ring", or Clow Corporation "Super-Lock". Restrained joints shall be capable of sustaining the specified design pressure. If thrust cannot be accommodated using restrained joints, such as bends adjacent to casing pipe, use approved thrust restraint devices.

Thrust at bends, tees, plugs, or other fittings shall be resisted using thrust restraint devices. Concrete thrust blocks are not allowed unless approved by theENGINEER. Acceptable thrust restraint devices shall be as manufactured by EBAA Iron, Ford Uni-Flange, or approved equal.

NOTE: At connection of new water line to existing main, both concrete thrust blocking (per Article II of these Specifications) and thrust restraint devices must be used.

Restrained joints and thrust restraint devices shall be used for a sufficient distance from each bend, tee, plug, or other fitting to resist thrust which will be developed at the design pressure of the pipe. For the purposes of thrust restraint, design pressure

shall be 1.5 times the design working pressure class indicated. Length of pipe with restrained joints and restraint devices shall be determined by pipe manufacturer and/or in accordance with the Handbook of Ductile Iron Pipe.

The following parameters shall be used: laying condition equal to AWWA C-600 Type 5 soil, safety factor of 1.8, a unit bearing resistance equal to zero, an a factor for polyethylene encasement as recommended by DIPRA, if required.

11. Pipe Trenching, Installation, And Backfill: Except as noted, Pipe Trenching, Installation, and Backfill for DIP shall be in accordance with AWWA C-600 and Article IV of these Specifications.

General: Any damage to Polyethylene wrap shall be repaired according to AWWA C-105. Pipe shall be kept clean during installation. Exposed ferrous metal which cannot be protected with field-applied tape coating, shall receive two coats of Koppers Bitumastic No. 50, or approved equal.

Pipe and fittings shall be installed to line and grade indicated. In areas where the line and grades indicated cannot be achieved using standard manufactured bends and fittings, make slight adjustments by deflecting joints according to the limitations of AWWA C-600.

Pipe Zone Embedment: Unless otherwise specified, Ductile Iron Pipe shall be embedded in Class II material as defined in Article IV. Native material or imported material meeting or exceeding Class II requirements may be used.

Marking Tape: Ductile Iron water pipe shall be marked by concurrently installing the appropriate marking tape for detection purposes. The detectable tape shall consist of a 5.0 mil inert polyethylene plastic material. It shall be high visibility blue with the standard warning and identification for potable water imprinted on the tape. The minimum width of detectable tape shall be 6-inches for all potable water lines. The burial depth shall be 36-inches, measured from finished grade. Detecting tape shall be manufactured by Empire, Lineguard, or approved equal.

Pipe Cutting: When required, the cutting shall be by machine, leaving a smooth cut at right angles to the axis of the pipe. Ends of cut pipe to be used with a push-on joint bell shall be beveled to comply with manufactured spigot end. Cement lining shall be undamaged.

Corrosion Protection: As a precaution against corrosion, all flanges, bolts, nuts and other exposed metal surfaces underground shall be coated with Texaco, Koppers, or equal rustproof compound.

12. Testing: Disinfect and test the piping system in accordance with Article VIII of these Specifications and as detailed in AWWA C-651.

C. Flowable Backfill. When required by governing agency, trenches shall be backfilled to the elevations shown, with flowable backfill as per Standard Specification "Flowable Backfill" Item 401.

- D. Cutting and Restoring Pavement.** Where water facilities must be installed in streets or other paved areas beyond limits of the roadway improvements, the work shall include saw-cutting of the pavement and base to neat lines and prompt replacement of these materials after water excavation and backfill are completed. The replacement materials, as to type and thickness, shall be as shown on the plans.

Any work done or damage to base and/or pavement outside the limits shown on the plans will not be measured for payment, but shall be restored at the CONTRACTOR's entire expense.

3. Measurement.

- A. Water Main (PVC).** This Item will be measured in place by the linear foot of PVC along the centerline of pipe as installed.
- B. Water Main (DI).** This Item will be measured in place by the linear foot of DI pipe along the centerline of pipe as installed.
- C. Flowable Backfill.** Refer to Standard Specification "Flowable Backfill" Item 401.4.
- D. Cutting and Restoring Pavement.** This will be measured by the square yard as shown under Item 400 "Excavation and Backfill for Structures."
- E. Abandon and Fill Existing Water Pipe.** This Item will be measured by the linear foot of existing water main pipe that is abandoned in place for the size indicated.

4. Payment.

- A. Water Main (PVC).** The work performed and the 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 (PVC)" of the type and size specified. This price shall be full compensation for furnishing all required materials, including all pipe, valves, fittings and accessories; mechanical joint restraints; and all appurtenances defined herein to include, but not limited to the following items: gate valves, tapping sleeves and valves, bonnet boxes, concrete collars, end plugs, bends, tees, couplings, reducers, marking tape, concrete thrust blocks, thrust restraint devices and all other items for the project not indicated as being covered under the other specific bid items shown on the proposal. All fittings and appurtenances shown on the Contract Drawings shall be considered subsidiary to the water pipe installation. Furnishing all required labor, including coordination, traffic control, potholing, excavation, including hand-digging, if needed; embedment and backfilling; compaction and compaction testing; flowable backfill, if required; disinfection, pressure testing, dewatering of groundwater, where required; cutting, capping, and connection of new water main to existing water lines.
- B. Water Main (DI).** The work performed and the 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 (DI)" of the type and size specified.

This price shall be full compensation for furnishing all required materials, including all pipe, valves, fittings and accessories; mechanical joint restraints; and all appurtenances defined herein to include, but not limited to the following items: gate valves, tapping

sleeves and valves, bonnet boxes, concrete collars, end plugs, bends, tees, couplings, reducers, marking tape, concrete thrust blocks, thrust restraint devices and all other items for the project not indicated as being covered under the other specific bid items shown on the proposal. All fittings and appurtenances shown on the Contract Drawings shall be considered subsidiary to the water pipe installation.

Furnishing all required labor, including coordination, traffic control, potholing, excavation, including hand-digging, if needed; embedment and backfilling; compaction and compaction testing; flowable backfill, if required; disinfection, pressure testing, dewatering of groundwater, where required; cutting, capping, and connection of new water main to existing water lines.

- C. Flowable Backfill.** Refer to Standard Specification “Flowable Backfill” Item 401.5.
- D. Cutting and Restoring Pavement.** Measured as provided under “Measurement” and will be paid for at the unit bid price for “Excavation and Backfill for Structures” Item 400.
- E. Abandon and Fill Existing Water Pipe.** The work performed and the materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Abandon and Fill Existing Water Pipe” of the size specified. This price shall be full compensation for furnishing all required materials, labor, and equipment, including but not limited to the following items: coordination, traffic control, potholing, excavation, complete draining (dewatering) of pipe, flowable backfill, cutting, capping, complete filling with approved flowable backfill of water mains to be abandoned, removal of bonnet boxes from abandoned valves, and all other items for the project not indicated as being covered under the other specific bid items shown on the proposal.

II. CONCRETE

1. Description. This Item specifies concrete uses for Water and Sewer Mains.

- A. Scope.** The CONTRACTOR shall furnish all materials, equipment, labor superintendence and incidentals necessary to mix and place concrete, consisting of Portland cement, fine aggregate, coarse aggregate, admixtures, and water in the proper proportions as specified herein. (May be superseded by governing agency)
- B. Quality Assurance.** Concrete shall be proportioned to give the necessary workability and strength and shall conform to the following requirements:

CLASS	MINIMUM 28-DAY COMPRESSIVE STRENGTH	MINIMUM CEMENT	MAXIMUM SIZE COARSE AGGREGATE	SLUMP (inches)
A	3,000 psi	5.5 bag/cy	¾"	3-1/2"
B	2,500 psi	4 bag/cy	1-1/2"	4"
C	4,000 psi	6 bag/cy	¾"	4"

The class designations provided above are as defined by the Utility.

Class A shall be used for curb, gutter, and sidewalk replacement, unless otherwise directed by the governing agency.

Class B shall be used for, thrust blocks, pipe encasement, ground anchors for piping and as noted in the plans.

Class C shall be used for cast in place sewer manhole bases, special structures or as required by manufacturer's specifications for pre-cast structures, unless otherwise indicated elsewhere in this special specification.

- C. Submittals.** Submit certified test reports regarding concrete mix design and reinforcing steel as may be required by the Contract Documents or the ENGINEER. Submit in a timely manner so as not to delay the project. Allow sufficient time for ENGINEER's review and resubmission, if necessary.
- D. Standards.** Concrete and related products shall comply with applicable requirements of the following:

ASTM C-33 Specification for Concrete Aggregates

ASTM C-150 Specification for Portland Cement

ASTM C-260 Specification for Air-Entraining Admixtures for Concrete.

ASTM C-494 Specification for Chemical Admixtures for Concrete.

2. Materials.

A. Portland Cement. Shall conform to ASTM C-150 for the appropriate required Type.

1. **Aggregates.** Shall conform to ASTM C-33. Fine aggregate shall consist of natural, washed, and screened sand having clean, hard, strong, durable, un-coated grains complying with ASTM C-33. Coarse aggregates shall comply with ASTM C-33 Size 467, Size 57, or Size 67. Local aggregates of proven durability may be used when acceptable to the ENGINEER.
2. **Air-Entraining Admixture.** Shall be used for concrete of 3,000 psi or greater and shall comply with ASTM C-260. The total average air content shall be in accordance with ACI 211.1.
3. **Water Reducing Admixture.** Shall be used when required by job conditions and shall comply with ASTM C-494. Use only admixtures which have been tested and accepted in mix designs, unless otherwise acceptable. Shall be used according to manufacturer's recommendations.
4. **Set Retarding Admixtures.** Shall comply with ASTM C-494 and be used with approval of the ENGINEER. Shall be used according to manufacturer's recommendations.
5. **Water.** Shall be clean and free from impurities. Drinking and ordinary household water is acceptable.

B. Manufactured Products. The forms shall be of wood or metal and shall be of sufficient strength to support the concrete without bulging between supports and sufficiently water tight to hold the concrete mortar. The forms shall be so constructed that the finished concrete shall be of the form and dimensions shown on the plans. All form work for exposed surfaces shall be of such material and so constructed so as to produce a smooth, even surface when the concrete is poured. All forms shall be oiled before use. In general, wall forms may be removed after the concrete has been in place for 24 hours. All exposed edges shall have a 3/4 inch chamfer whether or not so shown on the details. Immediately upon removal of the form, any honeycombed sections shall be repaired as directed.

Embedded Items. All bolts, pipe, pipe sleeves, inserts, or other fixtures, required by the plans or these specifications to be embedded in the concrete, shall be set accurately in place and maintained in such positions during concreting operations.

Reinforcing Steel. Metal reinforcements shall conform to the following requirements. Bar Reinforcement shall be round, deformed bars, Grade 60, conforming to either "Specification for Rail Steel Deformed and Plain Bars for Concrete Reinforcement" (ASTM A-616), or "Specifications for Axle Steel Deformed and Plain Bars for Concrete Reinforcement" (ASTM A-617).

Rail Steel Bars will be permitted only where bending is not required. All reinforcement bars shall be permanently marked with grade identification marks or shall, on delivery, be accompanied by a manufacturer's guarantee of grade that will identify variation.

Reinforcement stored on the site shall be protected from accumulation of grease, mud or other foreign matter and from rust producing conditions. Bars shall be free from rust, scale, oil, mud, or structural defects when incorporated in the structures. Reinforcements shall be accurately placed and securely held in place during placement of concrete in accordance with the ACI Detailing Manual.

- C. Concrete Thrust Blocking.** All underground piping shall be blocked with concrete, bearing solidly against undisturbed trench walls, at all changes in direction. This item is subsidiary to the installation of fittings, valves, and all other appurtenances requiring provisions for thrust restraint.

The concrete blocking shall be placed against undisturbed trench walls with a minimum 18-inches between trench wall and pipe. Blocking shall extend a minimum of 0.75 x pipe diameter below and above the centerline of pipe and shall not extend beyond any joints. Blockings shall be placed in accordance with the recommendations of "A Guide for the Installation of Ductile Iron Pipe" published by Cast Iron Pipe Research Association.

If requested by the ENGINEER, the ends of the thrust blocks shall be contained in wood or metal forms. Where upward thrusts are to be resisted, concrete anchor shall be reinforced.

Concrete used for Blocking shall be Class B. The minimum area of concrete bearing against undisturbed trench bank shall be in accordance with the following table:

BEARING SURFACE PER BEND		
PIPE SIZE	TEE, DEAD END, 90 DEGREE BEND	45 AND 22-1/2 DEGREE BEND
6"	4 sq. ft.	3 sq. ft.
8"	6 sq. ft.	3 sq. ft.
12"	13 sq. ft.	7 sq. ft.
16"	23 sq. ft.	12 sq. ft.
20"	37.02 sq. ft.	20.04 sq. ft.

- 3. Measurement.** This item will not be measured for payment as it is considered subsidiary to the various water mains bid items.

- 4. Payment.** The work performed and the materials furnished in accordance with this Item and measured as provided under “Measurement” will not be paid for individually as it is considered subsidiary to the various water mains and related appurtenances items. This shall include furnishing all required materials including concrete used for thrust blocking or anchoring fitting (bends, plugs, reducers, etc.), valves, fire hydrants, manholes, water services or water fire lines, and all other concrete items damaged by the CONTRACTOR due to negligence during the course of the project; and all hauling, mixing, manipulation, tools, labor, equipment, forming and incidentals necessary to complete the work.

III. GROUT

1. **Description.** This Item specifies grout uses other than masonry.
 - A. **Scope.** Where called for in the plans or specifications, the CONTRACTOR shall provide all labor, materials, equipment, and incidentals required for grouting.
 - B. **Standards.** Grout shall comply with applicable requirements of the following:
 - ASTM C-33 “Specification for Concrete Aggregates”
 - ASTM C-150 “Specification for Portland Cement”
2. **Materials.** Types of grout may include the following:
 - A. **Non-shrink, Epoxy Type:** Shall be a non-metallic, 100% solids, high strength epoxy grout such as Epoxite as manufactured by A.C. Horn Company, or Five Star Epoxy Grout by U.S. Grout Corporation, or equal.
 - B. **Non-shrink, Non-metallic Type:** Shall be a premixed non-staining cementitious grout requiring only the addition of water at the job site. Provide Darex In-Pakt Grout Pre-mix by A.C. Horn Company, or Masterflow 713 by Master Builders Company, or equal.
 - C. **Ordinary Cement-Sand Grout:** Consisting of one part by weight of Portland cement complying with ASTM C-150, Type V, to three parts by weight of clean sand of suitable gradation and complying with ASTM C-33.

At the CONTRACTOR’s option, ordinary grout may be of masonry cement, 4 sacks per cubic yard of clean sand, together with approved air-entraining agent and a minimum of clean water for placing. Where water repelling and shrinkage reducing requirements are shown or specified, use approved admixtures.
 - D. **Water:** Use clean, fresh, potable water free from injurious amounts of oils, acids, alkalies, or organic matter.
3. **Measurement.** This Item will not be measured for payment as it is considered subsidiary to the various water mains bid items.
4. **Payment.** This Item will not be paid individually as it is considered subsidiary to the various water mains bid items.

IV. EXCAVATION, INSTALLATION, AND BACKFILL

1. Description.

Trench Excavation and Preparation. Classification of excavation shall be “unclassified” and involves removing unnecessary materials and excavating trenches to the alignment, width, and depth as indicated in the plans or as required for the proper installation of the pipe and appurtenances. Adjacent structures shall be protected from damage by construction equipment. All excavated material shall be piled along the trench in a manner which will not endanger the work.

2. Materials.

A. Pipe Zone and Backfill Materials.

1. **Standards.** Embedment materials shall comply with applicable requirements of the following:

ASTM D-75 “Methods for Sampling Aggregates”, ASTM D-448 “Specification for Standard Sizes of Coarse Aggregate for Highway Construction”, ASTM D-2321 “Recommended Practice for Underground Installation of Flexible Thermoplastic Sewer Pipe”, ASTM D-2487 “Classification of Soils for Engineering Purposes”

2. **Definitions.** For the purpose of this specification, “pipe zone” shall define the area extending from the bottom of the trench bedding to 12-inches above the top of the pipe and to the undisturbed trench walls on either side of the pipe.

“Embedment” shall be defined as those vertical stratas of backfill material in the pipe zone consisting of bedding, haunching, and initial backfill, as defined in ASTM D-2321.

3. **Submittals.** Submittals shall include certified test reports for embedment material. Certified test reports shall be from an independent laboratory. Test reports shall include sieve analysis and Atterberg’s limits.

A gradation of Class I material shall be submitted by the CONTRACTOR to the ENGINEER for approval prior to use.

- B. **Pipe Zone Backfill.** Pipe zone embedment material shall be any of the following classes:

Class I material shall be manufactured angular, well-graded, crushed stone per ASTM D-2321, 1/4-inch to 3/4-inch size. The following materials shall be acceptable under this class designation: ASTM D-448 - Stone Sizes 4, 67, 5, 56, 57, and 6. Pea Gravel and other uniformly graded material are not acceptable under this class.

Class II material shall be coarse sands and gravels per ASTM D-2487 with maximum particle size of 3/4-inch, including variously graded sands and gravels, containing less than 5 percent fines (material passing the #200 sieve) generally granular and non-cohesive, either wet or dry. Soil Types GW, GP, SW and SP are included in this class.

Class III material shall be fine sand and clayey (clay filled) gravels, per ASTM D-2487, including fine sands, sand-clay mixtures, and gravel-clay mixtures. Class III includes soil Types GM, GC, SM and SC.

Under no circumstances shall Class IV or V material, as defined in ASTM D-2487, be used for embedment of flexible pipe.

Materials shall be classified according to The Unified Soil Classification System as defined in ASTM D-2487.

- C. Final Backfill.** Material for backfilling above the pipe zone shall be defined as follows, unless otherwise shown on the contract drawings or directed by the governing agency for the specific right-of-way:

Native. The most granular material excavated from the trench comprising the spoil bank may be used, provided it is devoid of rocks larger than three inches in greatest dimension, organic material, and other unsuitable material. If initially saturated during the excavation, the backfill shall be allowed to dry sufficiently, being manipulated if necessary, prior to placing back into trench, to achieve the specified compaction at plus or minus 2 percent of optimum moisture content.

Select. If material excavated from the trench is unsuitable as backfill material, or the required compaction is unattainable for the particular spoil backfill material, the CONTRACTOR shall, at his expense, import select material to be mixed with or used in place of the spoil material. Select material shall be designated as Class II as described in this Article.

Soil Cement. Where cement stabilized backfill is shown on the Drawings, or required by governing jurisdiction or utility, it shall consist of a mixture of soil or sand and 2 sacks of Portland cement per cubic yard. Soil shall be a sandy material, free from lumps, clods or organic material. If excavated material is not suitable, pit-run sand shall be used. Cement stabilized backfill shall be mixed in a concrete mixer or transit mixer.

3. Construction.

- A. Sources and Evaluation Testing.** Materials to be used for embedment and for backfill shall be obtained in accordance with a sampling plan and ASTM D-75. Testing of materials to certify conformance with specification requirements shall be performed by an independent testing laboratory approved by the ENGINEER, at the CONTRACTOR's expense. CONTRACTOR's testing agency shall perform tests upon change of source and at sufficient intervals to certify conformance of all material furnished for use on this project.

B. Trench Excavation and Preparation.

- 1. Trench Width.** The trench walls in the "pipe zone" shall be vertical.

Trench width for **FLEXIBLE PIPE** shall generally be:

FLEXIBLE PIPE - TRENCH WIDTH		
PIPE DIAMETER	TRENCH WIDTH = BARREL OUTER DIAMETER PLUS	
	Minimum	Maximum
Less than 24-in.	15 inches	18 inches
24 in. – 48 in.	18 inches	24 inches
Greater than 48 in.	24 inches	1/2" Pipe O.D.

Trench width at the top of the pipe for **RIGID PIPE** shall not exceed the outside diameter of the pipe barrel, plus the following allowance:

RIGID PIPE - TRENCH WIDTH	
PIPE DIAMETER	TRENCH WIDTH = BARREL OUTER DIAMETER PLUS
Less than 18-in.	16 in.
18 in. - 24 in.	19 in.
27 in. – 39 in.	22 in.
42-in. & Larger	½ Pipe O.D.

If maximum trench width specified above is exceeded at the top of the pipe, the CONTRACTOR shall provide, at his expense, additional load-bearing capacity by means of improved bedding, concrete cradle, cap, or encasement, or other means approved by the ENGINEER.

Trench walls above the pipe zone may be laid back or benched, where space permits, as necessary to satisfy the requirements of OSHA. Additional requirements for Trench Support are specified herein.

Wherever the prescribed maximum trench width is exceeded, the CONTRACTOR shall remove all loose and sloughed-in material from the trench and replace with compacted granular material such that haunching and initial backfill is compacted to at least 2.5 pipe diameters from either side of the pipe or to the trench walls at no additional cost to the ENGINEER.

Unless otherwise agreed upon, no additional payment will be made to the CONTRACTOR for extra material and labor required to fill excessive trench widths caused by the CONTRACTOR's equipment or natural collapse of trench walls.

2. **Trench Bottom.** Excavate the trench to an even grade so that the full length of the pipe barrel is supported and joints may be properly assembled.

For 30-inch diameter and smaller pipe, the trench shall be "rough cut" a minimum of 4-inches below the bottom of the pipe. For 33-inches and larger pipe, the trench shall be "rough cut" a minimum of 6-inches below the bottom of the pipe. The "rough cut" dimension shall be increased as necessary to provide a minimum clearance of 2-inches from the bottom of the trench to the bottom of the bells, flanges, valves, fittings, etc.

The entire foundation area at the bottom of all excavations shall be firm, stable material. Loose material shall be removed, leaving a clean, flat trench bottom, and material shall not be disturbed below required subgrade except as hereinafter described.

If the subgrade is soft, spongy, disintegrated, or where the character of the foundation materials is such that a proper foundation cannot be achieved at the elevation specified, the CONTRACTOR shall deepen the excavation, not less than 6-inches to a depth where a satisfactory foundation may be obtained. The subgrade shall then be brought back to the required grade with Class I coarse gravel compacted to seventy percent (70%) relative density per ASTM D-4254.

3. **Over Excavation.** If the trench is excavated to a faulty grade (at a lower elevation than indicated), correct the faulty grade at no additional cost to the Utility, as specified below:

In uniform, stable dry soils; correct the faulty grade with Class II granular embedment material thoroughly compacted to ninety percent (90%) Modified Proctor Density per ASTM D-1557.

In soft spongy disintegrated soils, or where necessary to allow proper drainage, correct the faulty grade with Class I coarse gravel compacted to seventy percent (70%) of relative density.

4. **Rock Excavation.** When pipe is to be laid in rock cut, provide a clearance of at least 6-inches below parts of the pipe, valves or fittings. Provide adequate clearance at bell holes to permit proper jointing of pipe laid in rock trenches. Refill excavation to pipe grade with Class II granular embedment material compacted to ninety percent (90%) Modified Proctor Density. Unless specifically required and called for in the specifications, and with a permit issued by governing authorities, blasting shall not be permitted.
5. **Bell Holes.** Bell holes of ample dimension shall be dug in trenches at each joint of pipe to permit the jointing to be made properly, visually inspected, and so that the pipe will rest on the full length of the barrel.

- 6. Dewatering.** Dewater excavations so that the work is performed in dry conditions. CONTRACTOR is responsible for physically installing/drilling dewatering wells, laying of discharge piping, other preparatory work and the maintenance of the operating system.

Use coarse gravel and geo-synthetic material to maintain the integrity of pipe and embedment material. Geo-synthetic material must wrap completely around pipe and gravel.

The elevation of the groundwater level prior to dewatering shall be determined and recorded. Unless otherwise specified, the method of dewatering shall maintain a phreatic water surface a minimum of 18" below pipe grades. Should over-excavation be necessary due to unsuitable foundation conditions, the ground water shall be additionally lowered as necessary.

The water removed from trenches shall be conducted to natural drainage ways, drains, or storm sewers in such a manner as to prevent damage to adjacent property or to the public. Pumps of ample capacity and in duplicate must be provided to insure that once an excavation is dried, the water level remains below the trench depth until that portion of the work is completed. The CONTRACTOR shall be responsible for obtaining approval for discharge from the appropriate governing agency. Under no circumstances will the CONTRACTOR be permitted to discharge into the sanitary sewer system.

When dewatering on a particular project may affect the production of private wells along the route, the CONTRACTOR shall determine if any wells used for domestic purposes are affected by the dewatering and shall furnish potable water to any affected residents. CONTRACTOR shall prepare baseline water level analysis in area to confirm affect on private wells.

It is the responsibility of the CONTRACTOR to dispose of the water from the dewatering operation according to the conditions of the discharge permit. The CONTRACTOR shall coordinate the dewatering effort with El Paso Water Utilities Engineering staff, insofar as compliance with discharge permit is concerned, and where dewatering effluent will enter drainage ditches operated and maintained by the District.

Engines or engine generators used to run the dewatering pumps shall be equipped with residential grade silencers. The silencers shall have an attenuation range of 25 to 30 dBA as required by the El Paso Municipal Code, Title 9, Chapter 9.40.

CONTRACTOR shall submit to the ENGINEER, a dewatering plan indicating proposed locations of dewatering wells, pumping facilities, collector and discharge pipe-lines, and discharge points (names of ditches, laterals, etc.) for his records. The plan shall be available for El Paso County Water Improvement District No. 1 (EPCWID #1) approval and comments if discharging in to EPCWID#1 drains. To comply with the requirements of the discharge permit between the Owner and the EPCWID #1, the CONTRACTOR shall provide discharge monitoring points to El Paso Water Utilities (EPWU) personnel, who will obtain samples for laboratory analysis to check water quality limitations imposed by the permit.

The CONTRACTOR shall assist the Owner's personnel in recording pumping rates at dewatering wells, pump times, and flows and shall become familiar with the methods of measurements according to the following schedule:

DATA RECORDED	METHOD OF MEASUREMENT	FREQUENCY OF MEASUREMENT
Pumping Rate At Each Dewatering Well or Discharge Point	"California-Pipe Method"	Daily If Changes Occur
Pumping Time	Hours	Daily
Total Dissolved Solids (TDS)	PSB Laboratory	Monthly
Total Discharge	Rate x Time	Continuous

The data obtained shall be recorded by the CONTRACTOR on a standard data sheet, and submitted monthly to the EPCWID #1. The CONTRACTOR shall be responsible for coordination of all requirements with the EPCWID #1. EPCWID#1 inspection of dewatering system at anytime during project life.

The selected Bidder is required to submit a Dewatering Plan, a Final Schedule for Dewatering, and an estimate of fees due EPCWID #1 to the ENGINEER. The Plan is due within fifteen (15) working days from the date of the Notice to Proceed. The Plan is a mandatory Submittal and shall include the estimated quantities of dewatering for each month of the Project and the point(s) of discharge.

ENGINEER will review and approve the Dewatering Submittal and forward it, through the Owner, to the District. The Owner must receive the approved plan at least two weeks in advance of the planned dewatering operations. Dewatering Fees due are to be estimated on the following basis:

Non-refundable application fee of \$1,000, the Licensee shall pay to the District a minimum of seven (7) calendar days in advance of any discharge under this License a fee for the use of the District's Facilities equal to \$150 per acre-foot of groundwater estimated by the License that will be discharged into the District's Facilities during term of the agreement.

The Owner will prepay dewatering fees to EPCWID #1 based upon the estimates in the approved Submittal. The Owner is responsible for all Dewatering Fees, including those for water pumped in addition to the quantities presented in the approved Dewatering Plan.

The CONTRACTOR shall provide monthly reports of discharge quantities and quality (TDS and sulfates), which specific requirements may be more particularly described in the Technical Specifications, to the OWNER through the ENGINEER for submittal to EPCWID #1. CONTRACTOR responsible for resolving high TDS penalties with EPCWID#1.

7. **Trench Support.** Excavations shall be braced and sheeted to provide complete safety to persons working therein and bracing shall comply with applicable federal (OSHA), state and local laws and ordinances. All trenches exceeding 5-feet in depth, as measured from the ground surface at the highest side of the trench to the trench bottom, shall meet the requirements specified in the current OSHA Standards.

CONTRACTOR shall be fully responsible for providing sufficient and adequate bracing for excavations with respect to work under construction and to adjacent utility lines and private property. Where soil conditions within trench area require support, CONTRACTOR may elect to use tight sheeting, skeleton sheeting, stay bracing, trench jacks, movable trench shield, or other approved methods to support the trench during pipe installation operations such as bedding preparation, pipe laying, and backfilling of haunches and initial zone.

Whenever possible, trench support shall not extend below the pipe crown. Where trench support must extend below the crown, such support should either be left in place or consist of approved steel sheets which can be retracted with minimal disturbance. Remaining voids shall be treated with grout or granular embedment material.

When a movable trench shield is used, the trailing half of the shield should be notched to the height of the top of the pipe. This will allow the haunch area of the pipe to be compacted properly to the wall of the trench. Dragging of a trench shield at pipe grade may be done provided such practice does not disturb the bedding. Voids created by the shield shall be filled and compacted properly.

8. **Trenching in Public Right-of-Way.** Except where otherwise specified, indicated on the Plans, or approved in writing by the ENGINEER, the maximum length of open trench, where the construction is in any stage of completion, shall not exceed the length set forth in the following. The definition of "open trench" for the purposes of this description will include excavation, pipe laying, backfilling, and pavement replacement. The descriptions under the area designations are general in nature and may be amended in writing by the ENGINEER due to particular or peculiar field conditions.

BUSINESS DISTRICT AREAS – 300 LINEAR FEET: Store front areas.

COMMERCIAL AREAS – 300 LINEAR FEET: Industrial, shopping centers, churches, schools, hotels, motels, markets, gas stations, government and private office buildings, hospitals, fire and police stations, and nursing homes.

RESIDENTIAL AREAS - ONE (1) BLOCK OR 300 LINEAR FEET, WHICHEVER IS THE LEAST: Single and multi-family residences, apartments, and condominiums.

UNDEVELOPED AREAS – 1,500 LINEAR FEET: Parks, golf courses, farms, undeveloped subdivided land.

Any excavated areas shall be considered as “open trench” until all pavement replacement has been made, or until all trenches outside of pavement replacement areas have been backfilled and compacted in accordance with these Contract Documents. Trenches across streets shall be completely backfilled with temporary or permanent pavement in place within 72 hours after pipe laying. An open trench shall not be permitted overnight, unless adequately barricaded and approved by the ENGINEER.

CONTRACTOR shall provide steel plates with adequate trench shoring and bracing, designed to support traffic loads where required to bridge across trenches at street and alley crossings, commercial driveways, and residential driveways where trench backfill and temporary patch have not been completed during regular working hours. Safe and convenient passage for pedestrians shall be provided. The ENGINEER may designate a passage to be provided at any point he deems necessary. Access to fire stations, fire hydrants, and hospitals shall be maintained at all times.

C. Pipe Installation.

1. **General.** Pipe shall be laid true to lines and grades as indicated on the drawings. All pipe and fittings shall be inspected before laying in the trench. Clean all joint surfaces and soiled materials prior to connecting one another. As work progresses, maintain interior of pipes clean.
2. **Standard Cover:** Standard cover shall depend on the water main size and installation conditions. Standard cover shall generally be as follows:
 - 6-Inch & 8-Inch Diameter Main: Minimum of 4-foot cover from top of pipe to finished grade
 - 12-Inch & Larger Diameter Main: Minimum of 5-foot cover from top of pipe to finished grade
3. **Potholing:** Existing utilities shown on plans are for informational purposes only. Prior to new pipe installation, CONTRACTOR shall pothole all existing utilities and structures to confirm their location, depth, and size. In the event of conflict or discrepancy that affects the project design, CONTRACTOR shall notify the ENGINEER before proceeding with pipe installation in order to formulate a solution.
4. **Pipe Zone Embedment.** Unless otherwise specified or shown in the drawings, pipelines shall be embedded in either Class I, II, or III material defined in this Article and installed as here forth described. CONTRACTOR may use native or imported material for embedment provided material conforms to these Specifications.

Embedment materials shall be placed in lifts not exceeding 8-inches loose depth. Unless otherwise specified or directed in writing by the ENGINEER, all material in the embedment zone shall be homogeneous.

Bedding shall be placed to provide uniform and adequate longitudinal support under the pipe. Place the first lift of bedding material from the bottom of the trench to slightly above the bottom of the pipe grade. Unless otherwise shown in the drawings, bedding shall be a minimum of 4-inches in depth for pipe sizes 30-inches and smaller, and 6-inches for pipe sizes greater than 30-inches.

Material shall be true to line and grade with bell holes of ample dimension to permit pipe to rest on the full length of the barrel and to permit joint make-up and coating application at joints. Consolidate and compact the bedding material as described in Article IV, and lay pipe to indicated grade.

Place a second lift, and if required, subsequent lifts, of embedment material to the springline of pipe. This process shall be defined as **Haunching**. Material shall be sliced under the haunches of the pipe, carefully filling all voids, and using care to prevent movement of the pipe.

Place **Initial Backfill** using a third lift from the springline of the pipe to the pipe crown, and a fourth lift from the pipe crown to a point 12-inches above the pipe.

5. **Groundwater Installation.** In areas where the pipe is installed below existing or future ground water levels, Class I material shall be used throughout the pipe zone and enclosed with a layer of approved geotechnical filter fabric. The fabric shall be placed carefully along the bottom of the trench and up the side of the trench a sufficient distance to lap over the top of the completed pipe installation. Fabric shall lap a minimum of 3-feet in the longitudinal at the end of one roll and beginning of the next, and lap 2-feet in the transverse at the top of pipe, except that for trench widths greater than 3-feet measured at the top of pipe, the top overlap shall be 3-feet. Follow manufacturer's recommendations for installation. Fabric shall be either Mirafi 140N, Dupont Typar 3401, or approved equal.
6. **Embedment Class Schedule.** Unless otherwise shown in the project drawings, the Utility Standard Embedment Class designations for the pipe material types listed in this Article shall be used to define each particular pipe's Embedment Condition allowed under these specifications. The detail drawings shall be examined for additional information or other special bedding requirements.
7. **Consolidation Methods in Embedment Zone.** Embedment backfill shall be compacted by equipment that is suitable for the type of soil encountered, and is capable of producing the degree of compaction specified. Where applicable, backfill materials shall be moisture conditioned to produce the required degree of compaction.

Hand or mechanical tamping shall be used to compact Class II or III material used in bedding, haunching, and initial backfill, except that the use of mechanical tampers or vibratory compactors directly over the pipe in the embedment area is prohibited. Caution in the use of mechanical compactors in the haunch and initial backfill to 12-inches above the pipe, shall be exercised to avoid damaging or misaligning the pipe.

Flooding or jetting shall not be used for compaction of embedment material.

- 8. Compaction and Testing of Pipe Embedment Zone.** Class I material used in the embedment zone may be placed by loose dumping with a minimum of compactive effort, except that care should be taken to assure proper placement of material under the pipe haunches.

Class I material shall not specifically require testing unless directed by the ENGINEER, in which case, such test shall be measured by ASTM D-4254 by percent of relative density.

Class II material used in the embedment zone shall be compacted to a density of not less than 90% of Standard Proctor Density defined by ASTM D-698.

Class III material used in the embedment zone shall be compacted to a density of not less than 90% of Standard Proctor Density defined by ASTM D-698.

Moisture content in Class II or III material shall not exceed 3% over the optimum to assure proper compaction.

Unless otherwise directed by the ENGINEER, one compaction test in the embedment zone for Class II or III material shall be taken at 200-foot intervals along the trench on either side of the pipe, or at any other intervals as may be judged by the ENGINEER to be warranted by questionable installation conditions. For pipe sizes 8-inches to 12-inches diameter, the first test shall be performed on the side level with the top of pipe. For sizes 15-inches and larger, the first test shall be at the springline of the pipe. For all sizes, the second test shall be made at the top of the embedment zone.

- 9. Density Control and Laboratory Testing.** Unless otherwise specified, reference to “maximum dry density” shall mean maximum density defined by ASTM D-1557 or D-698. Determination of density of backfill in-place, shall be in accordance with the requirements of ASTM D-2922.

Unless otherwise specified, the ENGINEER shall select a soils testing laboratory to perform initial density testing of in-place backfill; the CONTRACTOR is responsible for all density testing of backfills, including tests found not to be within the minimum requirements of the specifications.

Laboratory materials testing, including but not limited to determination of Atterberg Limits, Proctor Curves, Grain Size Analysis, as well as laboratory certification of manufactured materials, shall be at the CONTRACTOR’s expense, and as further required by this Article.

CONTRACTOR shall notify the soils testing laboratory and TxDOT Field Inspection Department 24-hours in advance to obtain soil density tests to fulfill the compaction requirements of the project.

D. Final Backfill.

- 1. General.** As soon as practicable after laying and jointing of the pipe, the completion of embedment and the completion of structures, the trench shall be backfilled, in accordance to the governing agency for the area where the pipe was installed, or as shown on the drawings.

Take the necessary precautions to protect the pipe during backfilling operations.

Remove sheeting and shoring as backfilling operations progress. Incorporate methods so that a good bond is achieved between the backfill material and the undisturbed trench walls. Where sheeting or trench protection is intact below the top of pipe and their removal cause obvious damage to the bedding and haunching, it may be necessary to leave portions of sheeting or bracing in place.

Caution, in the use of mechanical compactors in the haunch and initial backfill to 12-inches above the pipe, shall be exercised to avoid damaging or misaligning the pipe. Provide at least 3-feet of compacted cover over the top of the pipe before the trench is wheel-loaded, and 4-feet of cover before using pneumatic hammers during compaction. Contact between the pipe and compaction equipment shall be avoided at all times.

- 2. Consolidation Methods.** Backfill above the pipe zone to surface subgrade shall be with backfill material as indicated on the drawings and described in this Article IV. Backfill above the pipe zone shall be compacted by mechanical means. Water consolidation (flooding) may be used if approved by ENGINEER.

For mechanical compaction, place the backfill material above the pipe zone in lifts not exceeding 8-inches loose depth, moisten or aerate to obtain optimum moisture, and compact to the required density as described in this Article IV.

The jetting method of water tamping will not be allowed.

When the ponding method of water tamping is permitted, backfill material above the pipe zone shall be placed in the trench not to exceed 3-feet loose depth, and flooded until free water is evident on the surface for at least two hours.

Approximately 1-foot of water shall then be placed in the trench and subsequent lifts shall be started by depositing backfill material in the water until a maximum lift of 3-feet is placed. Additional water shall then be added to the backfill material until free water is again evident as before. This procedure shall be repeated until the entire trench is filled and thoroughly settled.

- 3. Cement Stabilized Backfill.** Where the drawings indicate that backfill for trenches under roads, driveways, concrete slabs, and in the zone of excavation for structures shall be cement stabilized, the backfill material shall be stabilized with a minimum of 2 sacks per cubic yard of Portland cement of material placed. Cement stabilized soil shall be placed around all adjusted manholes and shall be subsidiary to the manhole installation. Use of Soil Cement Backfill at the discretion of the CONTRACTOR, without the ENGINEER's prior approval, or for over-excavated portions of the trenches shall be at the CONTRACTOR's cost.

Cement stabilized soil placed for adjusting manholes shall be subsidiary to the different manhole installation items.

4. **Compaction and Testing Final Backfill.** (This item may be superseded by the requirements of the governing agency where the pipe was installed). Under existing or proposed paved streets, final backfill shall be compacted to the following Modified Proctor Densities per ASTM D-1557 (refer to standard drawing details) “Typical Trench Backfill Detail under Existing or Proposed Paved Streets”:

ZONE	SOIL CONDITION	% OF PROCTOR
Top of Pipe Embedment to 18 in. Below Finished Subgrade	Native Material As Specified	90%
Top of Finished Subgrade to 18 in. Below Top of Subgrade	Cohesive Non-cohesive	90% 95%

For all backfill in the areas not in existing or proposed paved streets, density of not less than 85% ASTM D-1557 shall be obtained from top of pipe bedding to ground surface.

Compaction tests will be required on backfill under proposed or existing streets and easements, and shall generally be as follows, unless otherwise directed by the ENGINEER:

Tests at 8-inches below subgrade at 200-feet intervals and not less than two per street at this level.

One test for every 2-feet of vertical trench backfill between top of pipe bedding and 18-inches below subgrade, at 200-feet horizontal intervals and not less than two per street at each level.

Additional tests shall be taken by the OWNER as deemed necessary.

The provisions for selection of the testing laboratory and ENGINEER/CONTRACTOR responsibilities for density control as described in this Article IV shall apply to backfilling in this section.

4. **Measurement.**

Excavation and Backfill. This Item will not be measured, as it is subsidiary to the installation of the various water mains, sanitary sewer mains, and related appurtenances.

5. **Payment.**

Excavation and Backfill. The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be subsidiary to the various water mains, sanitary sewer mains, and related appurtenances, including all excavation, bedding, backfill for pipe zone (embedment), final backfill, compaction and compaction testing; including associated dewatering shall be subsidiary to the different materials and

sizes of water mains, sanitary sewer mains,, steel casings, valves, fittings and appurtenances, and service installation, including but not limited to excavation, embedment and final backfill for “Additional Fittings”. Additional Fittings item is described in Article V.

V. VALVES AND FITTINGS

- 1. Description.** The CONTRACTOR shall furnish all valves and fittings where indicated on the Plans, as called for in these Specifications, or as required for proper operation of the equipment in general. Unless otherwise indicated on the Plans or specified in other sections of these Specifications, valves and fittings shall conform to the requirements as specified herein.

Where proper operation and utilization of equipment and facilities require installation of valves not indicated or specified, the CONTRACTOR shall provide and install, upon acceptance by the ENGINEER, valves similar and comparable to valves specified for similar and comparable duty in other parts of the project.

Quality Assurance. Valves shall conform to American National Standards Institute / National Sanitation Foundation (ANSI/NSF) Standard 61 "Drinking Water system Components - Health Effects" and be certified by an organization accredited by ANSI. Such compliance shall be evidenced by an affidavit from the manufacturer or vendor. If the pipe does not presently conform to this standard, information from the manufacturer regarding action being taken to comply with this standard must be submitted. All valves installed in a given line shall be designed to withstand the test pressure for that particular line and shall be fabricated with ends to fit the piping.

- 2. Materials.** All materials shall conform to the pertinent material requirements of the following Items. Complete shop drawings and specifications shall be furnished prior to acceptance and approval of the bid proposal. If requested, the valve manufacturer shall also submit a list of similar installations that have been in satisfactory operation for at least three years.

The manufacturer shall furnish a complete set of installation, operation, and maintenance instructions for each type of valve furnished. Instructions shall be bound in a cover.

A. Valves.

- 1. Non-Rising Stem Double Disc Gate Valves.** Non-Rising Stem Gate Valves are to be iron-body, bronze mounted, parallel seat internal wedging type with non-rising stem and designed for a gauge working pressure of 200 psig. NRS gate valves shall comply with AWWA C-500 "Gate Valves for Water and Sewage Systems", latest revision.

Valves 12-inches or smaller shall be for horizontal installation. The number of turns to open shall be a minimum of three times the valve diameter.

Acceptable manufacturers and models shall be:

American-Darling	52NRS (Flanged Ends), 55NRS (Mechanical Joint Ends)
Clow	F5065 (Mechanical Joint Ends), F5070 (Flanged Ends)
Kennedy	561X (Flanged Ends), 571X (Mechanical Joint Ends)
M&H	Style 67NRS

Mueller A-2380-6 (Flanged), A-2380-20 (Mechanical Joint Ends)

Submittals. Submittals shall be provided for approval. Also, the manufacturer shall provide an Affidavit of Compliance in accordance with Section 6.3 of AWWA Standard C-500. Records of all tests performed in accordance with Section 5.1 of AWWA Standard C-500 shall be provided. These records will be representative test results per Section 5.1 of AWWA Standard C-500. An affidavit of testing for the valve assembly as outlined in Section 6.3 of AWWA Standard C-500 300 ft-lbs shall also be provided.

Markings. Shall be cast on the bonnet or body of each valve. Markings shall include the manufacturer's name or mark, the year the valve casting was made, the size of the valves, and the designated working pressure.

Valve Ends. Valve ends shall be mechanical joint or flanged with drilling in compliance with ANSI B16.1. Valve ends and size as specified.

Valve Body and Bonnet. Shall be cast iron conforming to ASTM A-126 Class B, or ductile iron conforming to ASTM A-395 or ASTM A-536.

Gate. Shall be cast iron or Grade A bronze. Gate rings, constructed of Grade A bronze, shall be rolled, peened, or pressed into grooves machined in the discs, or may be fastened by some other accepted method.

Body-Seat Ring. Shall be constructed of Grade A bronze, and shall be back-faced threaded and machined screwed into the valve body.

Wedges. Double-disc gate valves shall be equipped with a free and positive-operating internal device that will press the disc seats firmly against the body seats when the valve is closed and release the load before the discs begin to move when the valve is opened. Wedges shall be simple and rugged in design. The wedge material shall be as specified in AWWA C-500 and contact surface shall not be iron to iron.

Valve Stem. Shall be constructed of low zinc bronze CDA Copper Alloy No. C99500 with a minimum yield strength of 40,000 psi and minimum elongation in 2-inches of 10%.

Stem Seals. Shall consist of two O-rings such that the seal above the stem collar can be replaced with the valve under pressure in the fully open position. O-rings shall meet the requirements of ASTM D-2000 and have physical properties suitable for the application.

Valve Operator. Shall be a cast iron, ASTM A-126 Class B, wrench nut. The nut shall have a 2-inch square base and shall be 1-15/16" square at the top and be 1-3/4 inch high and shall open counterclockwise (left). The wrench nut shall be painted black and an arrow indicating direction of opening shall be cast on the nut, according to AWWA C-509.

Protective Coating. An epoxy coating shall be applied to all exterior and all stationary interior ferrous surfaces including all interior openings in the valves body. The coating shall not be applied to the gasket surfaces of the end flanges.

The coating shall be applied in accordance with AWWA C-550 and the manufacturer's instructions. After the coating is completely cured, the coated surface shall be tested for porosity, holidays, and pinholes using a holiday detector. All holidays or irregularities shall be repaired and the coating again tested.

2. **Outside Screw and Yoke (OS&Y) Gate Valves.** Outside Screw and Yoke Gate Valves are to be iron-body, bronze mounted, parallel seat internal wedging type with outside screw and yoke and shall comply with AWWA C-500 "Gate Valves for Water and Sewage Systems". OS&Y Gate Valves shall be provided for the size specified.

Acceptable manufacturers and models shall be:

American Darling	52 OS&Y
Clow	F5072
Kennedy	566
M&H	STYLE 68
Mueller	A-2483-6

Submittals. Submittals shall be provided for approval. Also, the manufacturer shall provide an Affidavit of Compliance in accordance with AWWA Standard C-500 Section 6.3. Records of all tests performed in accordance with AWWA Standard C-500 Section 5.1, shall be provided. These records will be representative test results for AWWA Standard C-500 Section 5.1. An affidavit of testing for the valve assembly as outlined in Section 6.3 of AWWA Standard C-500 (300 ft-lbs), shall also be provided.

Markings. Shall be cast on the bonnet or body of each valve. Markings shall include the manufacture's name or mark, the year the valve casting was made, the size of the valves and the designated working pressure.

Valve Ends. Valves ends shall be flanged, with drilling in compliance with ANSI B16.1, or as otherwise specified.

Valve Body and Bonnet. Shall be cast iron conforming to ASTM A-126 Class B, or ductile iron conforming to ASTM A-395 or ASTM A-536.

Gate. Shall be cast iron or Grade A bronze. Gate rings, constructed of Grade A bronze, shall be rolled, peened, or pressed into grooves machined in the discs, or may be fastened by some other accepted method.

Body-Seat Ring. Shall be constructed of Grade A bronze, and shall be back-faced threaded and machined screwed into the valve body.

Wedges. Double-disc gate valves shall be equipped with a free and positive-operating internal device that will press the disc seats firmly against the body seats when the valve is closed and release the load before the discs begin to move when the valve is opened. Wedges shall be simple and rugged in design. The wedge material shall be as specified in AWWA C-500 and contact surface shall not be iron to iron.

Valve Stem. Shall be constructed of low zinc bronze CDA Copper Alloy No. C99500 with a minimum yield strength of 40,000 psi and minimum elongation in 2-inches of 10%. The opening through the bonnet for the stem shall be bushed with grade A, B, C, D, or E bronze as defined in AWWA C-500.

Yoke. The yoke may be either integral or bolted on to bonnet. The design shall be such that a hand may not be jammed between the yoke and handwheel.

Valve Operator. Shall be a cast iron, ASTM A-126 Class B, wrench nut. The nut shall have a 2-inch square base and shall be 1-15/16" square at the top and be 1-3/4 inch high and shall open counterclockwise (left). The wrench nut shall be painted black and an arrow indicating direction of opening shall be cast on the nut, according to AWWA C-509.

Protective Coating. An epoxy coating shall be applied to all exterior and all stationary interior ferrous surfaces including all interior openings in the valves body. The coating shall not be applied to the gasket surfaces of the end flanges.

The coating shall be applied in accordance with AWWA C-550 and the manufacturer's instructions. After the coating is completely cured, the coated surface shall be tested for porosity, holidays, and pinholes using a holiday detector. All holidays or irregularities shall be repaired and the coating again tested.

3. **Tapping Valves.** Tapping Valves are to be iron-body, bronze mounted, parallel seat internal wedging type with non-rising stem. Tapping Valves shall conform to AWWA C-500 "Gate Valves for Water and Sewage Systems" except that tapping valves shall have over-sized seat rings to accommodate full size cutters. Tapping Valves shall be provided for the size specified.

Acceptable manufacturers and models shall be:

American Darling	565
Clow	2640 (Figure F-6114)
Kennedy	8950 KEN-SEAL II
M&H	STYLE 751
Mueller	H-667

The number of turns to open shall be a minimum of three times the valve diameter.

Submittals. Submittals shall be provided for approval. Also, the manufacturer shall provide an Affidavit of Compliance in accordance with AWWA Standard C-500 Section 6.3. Records of all tests performed in accordance with AWWA Standard C-500 Section 5.1 shall be provided. These records will be representative test results for AWWA Standard C-500 Section 5.1 and certificate of testing for Section 6.3. An affidavit of testing for the valve assembly as outlined in Section 6.3 of AWWA Standard C-500 shall also be provided.

Markings. Shall be cast on the bonnet or body of each valve. Markings shall include the manufacturer's name or mark, the year the valve casting was made, the size of the valves, and the designated working pressure.

Valve Ends. Outlet end of the valve shall be mechanical joint or as otherwise specified.

Valve Body and Bonnet. Shall be cast iron conforming to ASTM A-126 Class B, or ductile iron conforming to ASTM A-395 or ASTM A-536.

Gate. Shall be cast iron or Grade A bronze. Gate rings, constructed of Grade A bronze, shall be rolled, peened, or pressed into grooves machined in the discs, or may be fastened by some other accepted method.

Body-Seat Ring. Shall be constructed of Grade A bronze, and shall be back-faced threaded and machined screwed into the valve body.

Wedges. Double-disc gate valves shall be equipped with a free and positive-operating internal device that will press the disc seats firmly against the body seats when the valve is closed and release the load before the discs begin to move when the valve is opened. Wedges shall be simple and rugged in design. The wedge material shall be as specified in AWWA C-500 and contact surface shall not be iron to iron.

Valve Stem. Shall be constructed of low zinc bronze CDA Copper Alloy No. C99500 with a minimum yield strength of 40,000 psi and minimum elongation in 2-inches of 10%.

Stem Seals. Shall consist of two O-rings such that the seal above the stem collar can be replaced with the valve under pressure in the fully open position. O-rings shall meet the requirements of ASTM D-2000 and have physical properties suitable for the application.

Valve Operator. Shall be a cast iron, ASTM A-126 Class B, wrench nut. The nut shall have a 2-inch square base and shall be 1-15/16" square at the top and be 1-3/4-inch high and shall open counterclockwise (left). The wrench nut shall be painted black and an arrow indicating direction of opening shall be cast on the nut, according to AWWA C-509.

Protective Coating. An epoxy coating shall be applied to all exterior and all stationary interior ferrous surfaces including all interior openings in the valves body. The coating shall be applied in accordance with AWWA C-550 and the manufacturer's instructions.

After the coating is completely cured, the coated surface shall be tested for porosity, holidays, and pinholes using a holiday detector. All holidays or irregularities shall be repaired and the coating again tested.

4. **Non-Rising Stem (NRS) Resilient-Seated Gate Valves.** Non-Rising Stem Gate Valves are to be resilient seat, non-rising stem and shall have a minimum rated gauge working pressure of 200 psig and shall comply with AWWA C-509 “Resilient-Seated Gate Valves for Water and Sewage Systems” and AWWA C-550 “Standard for Protective Coatings for Valves and Hydrants”. The valves design shall not have any recesses, insets in the bottom of the waterway that would promote build-up or collection of residue and debris. Resilient Seated Gate Valves shall be provided for the size specified.

With the valve open, the valve shall provide an unobstructed waterway that has a diameter not less than the full nominal diameter of the valve. The minimum number of turns to open the valve shall be three times the valve diameter.

Acceptable manufacturers and models shall be:

American Flow Control	Series 500, Series 2500
Clow	2640 (Figure F-6100)
Kennedy	KEN-SEAL II
M&H	3067
US Pipe	METROSEAL 250
Mueller	A-2360

Submittals. Submittals shall be provided for approval. Also, the manufacturer shall provide approved certified test data or an affidavit stating that the valve complies with AWWA C-509 Section 5.1 and the following, in accordance with AWWA C-509 Section 6.3:

Hydrostatic Test. The manufacturer shall pressure test one valve of each size and class with 400 psi applied to one side and zero to the other. The test shall be made in each direction across the closed gate.

Torque Test. The manufacturer shall over-torque a valve of each size to demonstrate that no distortion of the valve stem occurs. The applied torque shall be 250 ft-lb for a 4-inch valve and 350 ft-lb for the larger valves in both the open and closed position.

Leakage Test. The manufacturer shall select two valves of each size to be fully opened and closed for 500 complete cycles with a 200 psi differential pressure across the gate. The valve shall be drip tight upon completion of the test.

Pressure Test. One valve of each size shall be tested, with the gate fully open, to a pressure of 500 psi. There shall be no evidence of rupture or cracking of valve body, bonnet or seal plated.

Markings. Shall be cast on the bonnet or body of each valve. Markings shall include the manufacture's name or mark, the year the valve casting was made, the size of the valves, and the designated working pressure.

Valve Ends. Shall be mechanical joint or flanged ends as specified.

Valve Body and Bonnet. Shall be cast iron conforming to ASTM A-126, or ductile iron conforming to ASTM A-536 or A-395.

Bolts. All bonnet and seal plate bolts shall be factory installed and made from stainless steel ASTM A-276 with either regular-square or hexagonal heads with dimensions conforming to ANSI B18.2.1.

Wedge. The wedge shall be cast iron or ductile iron fully encapsulated with resilient rubber material bonded to the disc. The method for bonding the resilient material shall be confirmed by ASTM D-429 as required by AWWA C-509.

Valve Stem. Shall be constructed of low zinc bronze CDA Copper Alloy No. C99500 with a minimum yield strength of 40,000 psi and minimum elongation in 2 inches of 10%.

Stem Seals. Shall consist of two O-rings such that the seal above the stem collar can be replaced with the valve under pressure in the fully open position. O-rings shall meet the requirements of ASTM D-2000 and have physical properties suitable for the application.

Valve Operator. Shall be a cast iron, ASTM A-126 Class B, wrench nut. The nut shall have a 2-inch square base and shall be 1-15/16" square at the top and be 1-3/4 inch high and shall open counterclockwise (left). The wrench nut shall be painted black and an arrow indicating direction of opening shall be cast on the nut, according to AWWA C-509.

Protective Coating. An epoxy coating shall be applied to all exterior and all stationary interior ferrous surfaces including all interior openings in the valves body. The coating shall not be applied to the gasket surfaces of the end flanges.

The coating shall be applied in accordance with AWWA C-550 and the manufacturer's instructions. The epoxy coating shall have a minimum dry film thickness of 8 mils. After the coating is completely cured, the coated surface shall be tested for porosity, holidays, and pinholes using a holiday detector. All holidays or irregularities shall be repaired and the coating again tested.

5. **Butterfly Valves.** Shall be of the tight-closing, rubber-seated type for Class 150B service. Butterfly valves shall comply with the requirements of AWWA C-504, "Standard for Rubber-Seated Butterfly Valves". Butterfly valves shall be provided for the size specified.

Acceptable manufacturers and models shall be:

American-Darling Class 150B Flanged or Mechanical Joint

M&H 450, 4500, 1450

Kennedy 30A, 30C

Mueller Lineseal III

Pratt Groundhog Flanged

Submittals. Submittals shall be provided for approval. Also, the Manufacturer shall provide approved certified test data or an affidavit stating that the valve complies with the performance tests, leakage tests, hydrostatic test and proof-of-design tests as described in Sections 5.2 and 6/3 of AWWA C-504.

Valve Ends. Shall be short body flanged, mechanical joint or as otherwise specified.

Valve Bodies. Shall be constructed of cast iron ASTM A-126, Class B, or ASTM A-48, Class 40 or Ductile Iron, ASTM A-536, Grade 65/45/12.

Valve Discs. Shall be cast iron conforming to ASTM A-126, Class B or Ductile Iron conforming to ASTM A-536, Grade 65/45/12. Valve disc shall seat in a position of 90 degrees to the pipe axis and shall rotate 90 degrees between full open and tight closed position. Dimensions of clearance for valve discs are required.

Valve Shafts, keys, dowel pins, or taper pins used for attaching valve shaft to the valve disc shall be Type 304 or 316 Stainless Steel, conforming to ASTM A-276, or equivalent corrosion resistant material. All portions of shaft bearings shall be stainless steel or bronze.

Valve shafts may consist of a one-piece unit extending completely through the valve disc, or may be of the “stub shaft” type as defined in AWWA C-504.

Butterfly valves shall be provided with an extended bonnet, unless otherwise specified.

Shaft Seals. Shall be a Split-V or O-ring type. Replacement shall be possible without removing the valve shaft.

Valve Seats. Shall be new natural or synthetic rubber resilient seats to provide tight shut off at the specified pressure. Seats shall be attached to either the disc or the body. Seats shall be clamped, mechanically secured, bonded or vulcanized to either the disc or body. Seat rings shall be stainless steel and fastened by stainless steel cap screws.

Mating Seat Surface. Shall be ASTM A-276, stainless steel 18-8, Type 304, or have a 95% pure nickel overlay.

Valve Bearings. Shall be sleeve type. Bearings shall be manufactured from corrosion resistant, and “self-lubricated” materials that will not damage natural or synthetic rubber.

Valve Operators. Shall be manual with a 2-inch square operating-nut and turn left (counterclockwise) to open. Operators shall have all gearing totally enclosed and shall be pre-lubricated or grease packed. Operators shall be of the worm gear or traveling nut and link type with field adjustable stops capable of withstanding 300 ft. lbs. input torque, as required by AWWA C-504.

Protective Coating. Except as otherwise specified, all interior steel or cast iron surfaces shall be shop coated in accordance with the requirements of AWWA Standard C-504. All external surfaces for buried valves shall be shop coated with two coats of asphalt varnish according to AWWA C-504.

When specified, a standard epoxy interior coating shall be applied in accordance with AWWA Standard C-550, "Standard for Protective Interior Coatings for Valves and Hydrants".

- 6. Air Release, Air/Vacuum, And Combination Air Valves:** Air-Release, Air/Vacuum and Combination Air Valves shall comply with AWWA C-512 and the following specifications. These specifications shall apply to valve sizes 6" and smaller.

Air Release Valves (AR) shall be designed to automatically release accumulated air pockets within the pipeline while in operation and under pressure. Air release valves shall be APCO Model 200, Val-Matic Model 38, or Crispin Model P.

Air/Vacuum Valves (AV) shall be designed to allow large volumes of air to escape through the valve orifice when filling a pipeline and to close watertight once the air has been expelled. Air and vacuum valves shall also permit large volumes of air to enter through the valve orifice when the pipeline is being drained to break the vacuum. Air and vacuum valves shall be APCO Series 140, Val-Matic Series 100, or Crispin Model AL.

Combination Air Valves (CAV) shall be heavy-duty air and vacuum valves with air release. Combination Air Valves shall be designed to release accumulations of air at high points within a pipeline by exhausting large volumes of air as the pipeline is being filled and by releasing accumulated pockets of air while the pipeline is in operation and under pressure. Combination air valves shall also be designed to permit large volumes of air to enter the pipeline during pipeline drainage. Combination Air Valves shall be APCO, Val-matic Series 200, or Crispin Model C.

Submittals: The manufacturer shall provide an affidavit stating that the valve and all materials used in its construction conform to the applicable requirements of AWWA C-512 and these specifications. When required, the manufacturer shall provide an affidavit stating that the valve has been tested and is in compliance with the requirements specified in Section 5.1 of AWWA C-512.

Markings: Manufacturer's name or trademark, size of valve, and the designated maximum working pressure rating shall be cast in the body or marked on a corrosion-resistant name plate.

Body and Cover: Each air valve shall have a cast or ductile iron body and cover. Cast iron shall comply with ASTM A-126 Class B, or ASTM A-48 Class 35. Ductile iron shall comply with the requirements of ASTM A-536, Grade 65-45-12. Bolting material shall meet or exceed the strength requirements of ASTM A-307. All internal trim shall be of stainless steel.

Float: Shall be stainless steel. Float shall be baffled to prevent air from blowing valve closed until air is exhausted. Valve body, float, etc., shall be designed for a working pressure equal to that of the system in which it is installed. Floats for valves with inlet sizes less than 4" shall be capable of withstanding a collapse pressure of 1000 psig. For larger inlet sizes, floats shall be capable of withstanding a collapse pressure of 750 psig.

Valve Outlet: Shall be fitted to attach discharge pipe as indicated. Valve inlet shall be N.P.T. for 2-inch and smaller valves. Valve inlet shall be ANSI flange for 3-inch and larger valves. Flange rating shall equal or exceed the maximum working pressure of the system in which it is installed.

Installation: Air release and air/vacuum valves shall be installed within valve vaults, or manhole, in accordance with Utility Standard Details 263-1, 263-2, 263-3, 263-4 and plans.

Protective Coatings: Interior surface coatings shall not be required unless otherwise specified. External surfaces shall be coated with the manufacturer's standard primer.

- 7. Swing Check Valves:** Shall comply with the requirements of AWWA C-508 and be tight seating to prevent the backflow of the media during pump shut-off or power failure. The closure assembly shall be designed to assume the closed position by gravity under no flow conditions in a horizontal position. Fully open swing check valves shall have a net flow area not less than the area of a circle with a diameter equal to the nominal pipe size. Check valves shall be either Swing Type Spring and Lever or Swing Type Lever and Weight.

Acceptable Manufacturers shall be Kennedy Company, Mueller, or equal.

All internals shall be replaceable in the field without removing the main valve from the pipeline.

Valves 2-1/2 inches to 12 inches in diameter shall withstand a working pressure of 175 psig.

Submittals: The manufacturer shall provide an affidavit stating that the valve and all materials used in its construction conform to the applicable requirements of AWWA C-508 and these specifications. When required, the manufacturer shall provide an affidavit stating that the valve has been tested and is in compliance with the requirements specified in Section 5.2 of AWWA C-508.

Markings: Shall be cast on the cover or body and show the manufacturer's name or mark, check valve size, working water pressure, and flow-direction arrow.

Valve Ends: Shall be flanged unless otherwise specified.

Body: Shall be heavy cast-iron conforming to ASTM Standard A-126, Class B.

Disc: Disc shall be cast-iron conforming to ASTM Standard A-126, Class B. The disc shall be either Rubber-Faced, or Bronze-Faced conforming to ASTM B-584 "Specification for Copper Alloy Sand Castings for General Applications".

Disc Seat or Plate: Shall be resilient Buna-N material or Bronze conforming to ASTM Standard B-62 for drip tight shut-off and shall be easily replace in the field without the use of special tools.

Seat Ring: Shall be Bronze conforming to ASTM Standard B-584 and shall be mechanically attached to machined surfaces in the body.

Hinge or Clapper Arm: Shall be bronze conforming to ASTM Standard B-584.

Hinge Pins: Shall be Stainless Steel conforming to ASTM A-276 "Specification for Stainless and Heat Resisting Steel Bars and Shapes" in accordance with AWWA C-508.

Lever: For Swing-Type Lever and Weight, the lever shall have an adjustable counterweight to control opening and closing of clapper arm. For Swing-Type Spring and Lever, lever shall have an adjustable spring tension to control opening and closing of clapper. Installation of lever shall be on either side of valve.

Protective Coating: An epoxy coating shall be applied to all stationary interior ferrous surfaces including all interior openings in the valves body. The coating shall not be applied to the gasket surfaces of the end flanges. The coating shall be applied in accordance with AWWA C-550 and the manufacturer's instructions.

Valve Exterior: Shall be painted with Red Oxide Phenolic Primer Paint as accepted by the FDA for use on materials in contact with potable water.

- 8. Pressure Reducing Valves:** Shall maintain a constant downstream pressure regardless of varying inlet pressure. Unless otherwise specified, Water Pressure Reducing Valve shall be a direct acting, spring loaded, normally open globe pattern valve designed to permit flow when controlled pressure is less than the spring setting.

2-inches and Smaller: Shall be bronze body, nylon reinforced diaphragm, single seat, composition disc, Watt No. 223 or Masoneilan No. 227, or equal.

Larger than 2-inches: Shall have a cast iron body (conforming to ASTM B-61), bronze main valve trim (conforming to ASTM B-61), a reinforce neoprene diaphragm, stainless steel stem and flanged ends.

Acceptable Manufacturers and Models: Shall be Cla-Val Co., Model 90, Fisher Governor Co., Type 616 Bailey Model 30A, or approved equal.

Pressure Rating: Shall be 125 psi with an adjustment range of 30-300 psi.

Valve Components: Shall be removable and repairable while the valve body remains in the line.

Diaphragm Assembly: Shall be synthetic rubber with a stem fully guided at both ends by a bearing in the valve cover and an integral bearing in the valve seat. The diaphragm shall not be used as a seating surface.

Resilient Disc: Shall form a sealed chamber against the disc seat when the valve is closed. The seat shall be removable and shall have a smooth surface that will not induce seal cutting or wear.

Strainer: Valves 3-inches and smaller shall have a standard flow clean strainer mounted in the inlet supply port of the main valve.

Valves 4-inches and larger shall have a standard y-strainer externally mounted for the protection of the control circuit.

Protective Coating: An epoxy coating shall be applied to all interior and exterior ferrous surfaces of the valve body. The coating shall be applied in accordance with AWWA C-550 Standards.

- B. Fittings.** Fittings as specified herein shall be ductile iron (DI) for use with ductile iron and polyvinyl chloride (PVC) water pressure or transmission pipe.

All fittings shall be smooth cement lined in accordance with AWWA C-104 and shall be outside asphaltic coated per AWWA C-110. The size, body type, type of joint ends, and applicable reference standard, shall be as shown on engineering drawings or as specified.

Standards. Fittings shall comply with applicable requirements of the following:

ANSI B16.1 “Cast Iron Pipe Flanges and Fittings”, AWWA C-104 “American National Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water”, AWWA C-105 “Standard for Polyethylene Encasement for Ductile Iron Pipe and Fittings”, AWWA C-110 “American National Standard for Ductile-Iron and Gray-Iron Fittings, 3 In. Through 48 In., for Water and Other Liquids”, AWWA C-111 “Rubber-Gasket Joints”, AWWA C-153 “American National Standard for Ductile-Iron Compact Fittings, 3 In. Through 16 In., for Water and Other Liquids”

Minimum Requirements. The following minimum requirements of TABLE A and TABLE B shall apply to the specified fittings.

All joint accessories such as gaskets, glands, bolts, and nuts shall be furnished with mechanical joints, and gaskets and lubricant shall be furnished with push-on joints in sufficient quantity for assembly of each joint.

Push-on joint fittings shall be marked with the proprietary name or trademark of the joint.

Fittings shall be marked on the outside with their applicable AWWA Standard and information called for by the Standard.

Fittings shall be polyethylene wrapped in accordance with AWWA C-105.

TABLE A - STANDARD SHORT-BODY FITTINGS PER AWWA C-110			
TYPE OF JOINT	DIAMETER	RATE WORKING PRESSURE	MATERIAL
Mechanical (Rubber Gasket/C-111)	4-24 inches	350 psi	DI
Flanged	4-24 inches	250 psi	DI
All Types	30-80 inches	250 psi	DI
Push-On (Rubber-Gasket/C-111)	4-24 inches	250 psi	DI

TABLE B - COMPACT SHORT-BODY FITTINGS PER AWWA C-153			
TYPE OF JOINT	DIAMETER	RATE WORKING PRESSURE	MATERIAL
Mechanical or Push-On (Rubber Gasket/C-111)	4-24 inches	350 psi	DI

C. Valve Vaults.

- 1. GENERAL:** Pre-cast vaults shall be as shown on the Plans. Bases shall be pre-cast or cast-in-place as indicated on the Drawings.
- 2. QUALITY ASSURANCE:** Vaults shall meet the requirements of ACI 318. All vaults shall be designed for a minimum H-20 loading per AASHTO Specifications, plus a 30 percent impact factor, or greater if indicated on the Drawings or specified.

Mark date of manufacture and name or trademark of manufacturer on inside of each pre-cast vault section.

- 3. SUBMITTALS:** Structural calculations sealed by a Structural Engineer registered in the State of Texas shall be submitted for approval, along with Shop Drawings.
- 4. PRODUCTS AND MATERIALS:** Concrete shall have a minimum 28-day compressive strength of 4,000 psi. Reinforcing steel shall meet the requirements of Article II.

An approved flexible joint shall be provided between each pipe entering and exiting the vault. The joint shall provide a watertight installation. Submit jointing system or material for approval.

Metal frames, covers, steps, toe pockets and similar required items shall be provided as shown.

- 5. INSTALLATION:** Cast-in-place bases shall be placed on suitable foundations after the pipes are laid. Special care shall be taken in placing the concrete around the bottom of the pipes to obtain a waterproof structure. An approved bell shall be cast in the base to receive the pipe sections forming the barrel.

Pre-cast bases shall be set on a concrete or crushed stone foundation as shown. Pre-cast bases shall be set at the proper grade and carefully aligned. Set pre-cast vault sections vertical in true alignment. Install sections, joints, and gaskets in accordance with manufacturer's recommendations.

Lifting holes shall be sealed tight with a solid rubber plug driven into hole and the remaining void filled with cement-sand mortar.

3. **Provisions for Thrust.** All underground piping shall be blocked with concrete, bearing solidly against undisturbed trench walls, at all changes in direction, fittings, and valves. This item is subsidiary to the installation of fittings, valves, and all other appurtenances requiring provisions for thrust restraint.

The concrete blocking shall be placed against undisturbed trench walls with a minimum 18-inches between trench wall and pipe. Blocking shall extend a minimum of $0.75 \times$ pipe diameter below and above the centerline of pipe and shall not extend beyond any joints. Blockings shall be placed in accordance with the recommendations of "A Guide for the Installation of Ductile Iron Pipe" published by Cast Iron Pipe Research Association and according to details shown on construction plans.

If requested by the ENGINEER, the ends of the thrust blocks shall be contained in wood or metal forms as provided for under Item 420, "Concrete Structures". Where upward thrusts are to be resisted, concrete anchor shall be reinforced. All reinforcing steel shall conform to the provisions of Item 440, "Reinforcing Steel".

Concrete used for Blocking shall be Class B conforming to the provisions of Item 421, "Portland Cement Concrete". The minimum area of concrete bearing against undisturbed trench bank shall be in accordance with the following table:

BEARING SURFACE PER BEND		
PIPE SIZE	TEE, DEAD END, 90 DEGREE BEND	45 AND 22-1/2 DEGREE BEND
6-Inch	4 sq. ft.	3 sq. ft.
8-Inch	6 sq. ft.	3 sq. ft.
12-Inch	13 sq. ft.	7 sq. ft.
16-Inch	23 sq. ft.	12 sq. ft.
20-Inch	37.02 sq. ft.	20.04 sq. ft.

Mechanical joint restrainers shall be installed as specified. Mechanical Joint Restrainers shall be as manufactured by EBAA Iron, Uni-Flange, or approved equal.

4. Execution.

- A. **Valve Installation.** Carefully handle and install valves horizontally in such a manner as to prevent damage to any parts of the valves. Installation shall be in accordance with manufacturer's instruction. Valves delivered closed to the site shall be opened by the CONTRACTOR prior to installation.

The CONTRACTOR shall record the number of turns required to open the valve. This information shall be submitted to the Utility on the standard valve report.

Valves shall be polyethylene-wrapped in accordance with AWWA C-105, unless otherwise specified. Thrust blocking shall be provided as specified.

- B. Valve Testing.** Upon completion of installation of the valves, an acceptance test shall be conducted to verify the satisfactory operation of the valves. The unit shall be checked for operation and leakage. The valves must perform in a manner acceptable to the ENGINEER.

5. Measurement.

- A. Valves.** This Item is subsidiary to the various water mains and related appurtenances Item and will not be measured for individual payment.
- B. Fittings.** This Item is subsidiary to the various water mains and related appurtenances Items and will not be measured for individual payment.
- C. Additional Fittings.** This Item will be measured in place by the pound of additional fittings installed.

6. Payment.

- A. Valves.** The work performed and the materials furnished in accordance with this Item and measured as provided under “Measurement” will be not paid for individually as it is considered subsidiary to the various water mains Items. All valves shown on the drawings shall be subsidiary to the different pay items for water mains and services in this Contract and shall include all costs associated with coordination; excavation; disposal of excess material; backfill, compaction, compaction testing for utilities, all labor, equipment and materials required for furnishing and installing all valves shown on the Contract drawings to include those required as part of the different pay items, complete in place, including but not limited to: thrust blocking, mechanical joint restrainers, concrete anchoring, polyethylene wrapping, and provisions for corrosion protection. Use of mechanical joint restrainers in lieu of or in conjunction with concrete thrust blocking shall not be considered for additional compensation.
- B. Fittings.** The work performed and the materials furnished in accordance with this Item and measured as provided under “Measurement” will be not paid for individually as it is considered subsidiary to the various water mains Items. All fittings shown on the drawings shall be subsidiary to the different pay items for water mains and services in this Contract and shall include all costs associated with coordination; excavation; disposal of excess material; backfill, compaction, compaction testing for utilities, all labor, equipment and materials required for furnishing and installing all fittings shown on the Contract drawings to include those required as part of the different pay items, complete in place, including but not limited to: thrust blocking, mechanical joint restrainers, concrete anchoring, polyethylene wrapping, and provisions for corrosion protection. Use of mechanical joint restrainers in lieu of or in conjunction with concrete thrust blocking shall not be considered for additional compensation.

- C. Additional Fittings.** The work performed and the materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Additional Fittings”. This price shall be full compensation for furnishing all required materials, including all costs associated with coordination; excavation; backfill, compaction, compaction testing for utilities; disposal of excess material; equipment and materials required for cutting and removal of water mains, furnishing and installing additional valves, bends, tees, crosses, couplings, reducers, adaptors, flexible fittings, not originally shown on the Contract Drawings or drawing details, as deemed necessary by the Engineer, complete in place, including but not limited to: thrust blocking, mechanical joint restrainers, concrete anchoring, polyethylene wrapping, and provisions for corrosion protection. Additional fittings are based on the cost of material only. Labor costs shall be included in the unit price for Water Main (PVC) and/or Water Main (DI). Mechanical joint restrainers in lieu of or in conjunction with concrete thrust blocking shall not be considered for individual payment through the “Additional Fittings” provisions. The actual amount of additional fittings may be less than, but shall not exceed the total quantities allocated on the bid proposal without approval by the ENGINEER.

VI. WATER SERVICE CONNECTIONS

1. Description. This Item shall govern for the construction of water service connections and fire lines. CONTRACTOR shall furnish labor, materials, equipment and incidentals necessary to install water service connections and fire lines, complete for potable water supply. New water meters, unless otherwise specified, will be furnished by the Utility when required. All other materials required, including meter boxes, shall be furnished and installed by the CONTRACTOR. CONTRACTOR shall furnish labor, materials, equipment, and incidentals to fabricate, furnish, and install pre-cast concrete meter boxes and vaults.

2. Materials.

A. Submittals. Submittals shall include certifications from manufacturers that the products comply with appropriate ASTM, AWWA and Utility Standards. Submit shop drawings on meter boxes and associated hardware to the ENGINEER for approval prior to fabrication.

B. Materials.

1. Water Service Connections.

Castings and Washer Nuts. Shall be of certified cast bronze composition, 85-5-5-5 percent per ASTM B-62, fully formed, tapped threads meeting requirements of AWWA C-800 for underground service.

Gaskets. Shall be self-sealing, 100 percent neoprene or Buna-N rubber, formulated for water service.

Service Saddles. Shall be two or three piece all-bronze, double strap with National Coarse Class 2 thread. Saddles shall be suitable for Class 200 asbestos cement pipe, cast iron pipe and ductile iron pipe with double straps. Saddles for C-900 or C-905 polyvinyl chloride (PVC) pipe shall be single strap. Saddle body shall extend 180 degrees around pipe.

Acceptable manufacturers and models are as follows:

Ford Meter Box Co.	Model S90
James Jones Co.	J-996
A.Y. McDonald Mfg. Co.	3805
Mueller	H-1344X

Straps. Shall be silicon bronze, approximate tensile strength of 70,000 psi chamfered for easy nut starting and flattened to provide wide bearing surface.

Valves. Shall be in accordance with Utility acceptable standards and requirements for Gate Valves. Valves for copper pipe shall be bronze with minimum 85 percent copper content casting. Valves for PVC pipe shall be cast-iron and conform to requirements for Gate Valves, Article V.

Corporation stops shall be as manufactured by Ford Meter Box Co., Mueller, or approved equal and conform to the requirements of AWWA C800.

Angle ball valves with padlock wings shall be copper flared inlet and female iron pipe thread outlet such as James Jones Company Model J-1965W, McDonald MFG Model 4606B, or approved equal. Outlet meter coupling nut shall be used for 3/4-inch and 1-inch meters. Valves for 1-1/2-inch and 2-inch meters shall be inlet female iron pipe by outlet oval flange ends.

Service Pipe. Shall be copper Type “K” for sizes up to and including 2-inch, meeting ASTM B-88. Pipe for 3-inch services shall be 4-inch PVC per AWWA C-900, with reducers at meters. Pipe for 4-inch services and larger shall be PVC pipe per AWWA C-900. Fittings for copper pipe shall be bronze. Fittings for PVC pipe shall be ductile iron.

2. Meter Boxes. Concrete meter boxes shall meet the following standards:

ASTM A-27	Specifications for Steel Castings, Carbon, for General Application
ASTM A-36	Specification for Structural Steel
ASTM A-48	Specification for Gray Iron Castings
ASTM C-33	Specification for Concrete Aggregates
ASTM C-150	Specification for Portland Cement
ASTM C-309	Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C-615	Specification for Granite Building Stone

Submit shop drawings on molds, meter boxes, and associated hardware to the ENGINEER for approval prior to fabrication. Provide manufacturer’s certification that products comply with appropriate ASTM, AWWA, and Utility standard details.

The Owner reserves the right to request results of compressive tests, to inspect the manufacturing process at any time; to perform tests on materials used; and to extract cores from completed meter boxes for compressive strength testing and placement of reinforcement.

Cement shall be Portland cement conforming to ASTM C-150, Type I or Type III. Concrete shall have a minimum 28-day compressive strength of 4,500 psi; a water cement ratio of 0.5 or less by weight; and a maximum 5.5 gallons water per sack cement.

All concrete shall be handled from the mixer or transport vehicle to the place of final deposit in a continuous manner, as rapidly as practicable, and without segregation or loss of ingredients, until the operation is completed. Concrete shall be placed in layers not over 2-feet deep.

Each layer shall be compacted by mechanical internal or external vibrating equipment. Duration of the vibration cycle shall be limited to the time necessary to produce satisfactory consolidation without causing objectionable segregation.

Aggregates, other than lightweight aggregates, shall conform to specifications outlined by ASTM C-33. Aggregates shall be free of deleterious substances and graded in a manner as to produce a homogeneous concrete mix. All materials are to be accurately weighed at a central batching facility for mixture.

Curing for the purposes of early re-use of forms, the concrete may be heated in the mold, after initial set has taken place. The temperature shall not exceed 71.11°C (160 degrees Fahrenheit) and the temperature shall be raised from normal ambient temperatures at a rate not to exceed 4.44°C (40 degrees Fahrenheit) per hour. The cured unit shall not be removed from the forms until sufficient strength is obtained for the unit to withstand any structural strain that may be subjected during the form stripping operation. After the stripping of forms further curing by means of water spraying or a membrane curing compound may be used and shall be of a clear or white type, conforming to ASTM C-309.

Steel Reinforcing shall comply with ASTM A-615 Grade 60 steel, $F_Y = 60,000$ psi. Minimum concrete cover on re-bar top slab shall be 1.25-inch and 1.5-inch on re-bar for walls. Bar bending and placement to comply with latest ACI Standards. All reinforcing steel, including welded wire mesh, shall be of the size and in location as shown on the plans. All reinforcing shall be sufficiently tied to withstand displacement during the pouring operation. Lifters shall be designed to handle the imposed weights, and shall be placed as specified on the drawings or manufacturer's requirements.

Steel Frames and Covers shall conform to ASTM A-27, Grade 70-36. Structural welded steel shall conform to the requirements of ASTM A-36 with dimensions as specified on the drawings.

Cast Iron Ring and Covers shall conform to the requirements of ASTM 48, Class 30. All castings shall be of uniform quality, free from blowholes, shrinkage, distortion or other defects. They shall be smoothed and well cleaned by shot-blasting.

All castings shall be manufactured true to pattern. Component parts shall fit together in a satisfactory manner. Round frames and covers shall have continuously machined bearing surfaces to prevent rocking and rattling.

Tolerances shall not exceed 1/16-inch per foot. Deviation in weight shall not exceed 5 percent.

3. **Tapping Sleeves and Pipe Couplings.** The CONTRACTOR shall furnish labor, materials, equipment and incidentals necessary to install tapping sleeves and pipe couplings as specified. All tapping sleeves and pipe couplings furnished for incorporation in the work shall be suitable for operation at pressures as specified for the pipelines in which they will be installed, including test pressures and surge allowances.

Submittals. The CONTRACTOR shall furnish all necessary shop drawings as required.

Cast Tapping Sleeves. Tapping sleeves shall be of suitable construction and reinforced to provide resistance to line pressures. They shall be designed for the pipe size and material on which they will be used. Tapping sleeves shall be built in halves for assembly around the main to be tapped. The branch outlet shall have a flanged face for bolting to the tapping valve.

The inside diameter of outlet branch shall be sufficiently larger than the nominal size to provide clearance for the full size cutters of the tapping machine.

Acceptable manufacturers shall be:

Mueller Company

Kennedy Valve Squareseal

M&H

Type 1: Cast tapping sleeve allows water to circulate between the sleeve and the outside surface of the pipe. Gaskets of suitable material, designed for use on potable water shall form watertight joints along the entire length of the sleeve. Circumferential joints at the ends of the run of the sleeves shall be sealed by mechanical joints, conforming to AWWA C-111 as to dimensions, clearances, and materials, except that gaskets and glands form mechanical joints shall be totally confined or compressed between ridges or grooves extending continuously for the full length of both halves of the sleeve casting. Bolts shall be located close to the outside of the gaskets and spaced so as to exert sufficient pressure to form a watertight joint and withstand stresses imposed by the intended use.

Type 2: Water is confined to the immediate area of the tap opening. The outlet half of each sleeve shall be fitted with a continuous gasket of approximately circular cross section, permanently cemented into a groove surrounding the outlet opening. The back half of each sleeve shall be fitted with elastomeric pads, a metal shoe, or other device for developing adequate pressure on the gasket to prevent leakage at any pressure within the design capacity of the pipe.

Protective Coating: All surfaces exposed to flow shall be coated in accordance with AWWA C-550.

Fabricated Tapping Sleeves. Fabricated tapping sleeves shall be rated for a working pressure of 150 psi. All tapping sleeves shall meet the following requirements:

Acceptable manufacturers of fabricated tapping sleeves shall be:

Ford	FTSC
JCM	412
Romac	FTS 420

Markings: Each tapping sleeve shall be permanently marked to identify the outer diameter size range.

Test Plug: Shall be a 3/4" NPT with standard square head.

Nuts and Bolts: Shall be high strength, corrosion resistant 18-8 Type 304 Stainless Steel.

4" - 12": Tapping sleeve body and flange shall be 18-8 Type 304 Stainless Steel or AWWA C111 Carbon Steel with fusion epoxy coating. The body, lug, and gasket armor plate shall be in compliance with ASTM A-240. All metal surfaces shall be passivated, in accordance with ASTM A-380, after fabrication.

Gasket: Shall provide a watertight sealing surface around the full circumference of the pipe. Gaskets shall be formed of natural or synthetic rubber.

Lugs: Shall be welded to the shell and prevent alignment problems by allowing the bolts to pass through. Bolts shall not be welded to the sleeve.

16" and Larger: Tapping sleeves shall have a heavy welded steel body in compliance with ASTM A-36 or ASTM A-285, Grade C.

Gasket: Shall be natural or synthetic rubber compounded for water use and shall provide a watertight sealing surface.

Flange: Shall be constructed in accordance with AWWA C-207 Class D and shall be properly recessed for aligning the sleeve and tapping valves.

Protective Coating: Steel tapping sleeves shall be coated with epoxy. Minimum thickness shall be 8 mils.

Flexible Couplings. Shall be furnished and installed where shown on the drawings, specified, or in locations, as approved by the ENGINEER. Flexible couplings installed underground shall be ductile iron and Type 316 Stainless Steel nuts and bolts shall be used. When flexible couplings are used as expansion joints, the pipe ends shall be separated to allow for expansion. Where indicated on the drawings or required by field conditions, flexible couplings shall be suitable for connecting pipes having different outside diameters. Flanged coupling adapters shall be restrained with tie rods.

Protective Coating: Entire coupling assembly shall be given a 20 mil coating of T.C. Mastic as manufactured by Tape Coat Company, Bitumastic No. 50 as manufactured by Koppers Company, or approved equal.

Ductile Iron Pipe: Flexible Joint Couplings shall be Dresser Style 38, Rockwell Style 411, or equal. Flanged coupling adapters for ductile iron pipe shall be Dresser Type 127, Rockwell International 112, Baker Series 600, or equal.

Steel Pipe: Flexible couplings shall be Dresser Style 38, Rockwell International 411, or equal, except where other styles are required for special conditions.

Gaskets: Shall be neoprene rubber or equal.

Installation. Tapping sleeves shall be installed in accordance with the manufacturer's recommendations. Tapping valves shall meet the requirements of Article V, Gate Valves. Disc and seat ring shall be so constructed that the inside diameter of the ring is at least 3/16-inch larger than nominal size of valve. Tapping sleeve and valve assembly shall be blocked as indicated.

3. Execution.

- A. General.** Service taps for 3/4-inch to 2-inch services shall be made with service saddle to be furnished and installed by the CONTRACTOR. No direct taps, i.e. without the saddle, shall be made. Taps for 3-inch and 4-inch services shall be made using 4-inch tapping sleeve and valve. Copper service pipe attached to metallic water mains shall be insulated at the corporation stop with a dielectric insulator. Installation shall comply with Utility Standards for Excavating, Backfilling, and Compacting.

Multiple tapping, two or more taps on a length of pipe, shall not be on a common line parallel to the longitudinal axis of the pipe and shall be no closer than 18-inches on the longitudinal axis of the pipe.

No splices shall be allowed in any portion of the service pipe run between the main line connection and the meter assembly. All services shall be connected to new main by means of wet-tapping - no dry or direct taps are authorized.

Meter installations larger than 1-inch shall be made with a bypass meter connection according to the following schedule:

1-1/2-inch and 2-inch meters = 1-inch bypass

3-inch and 4-inch meters = 2-inch bypass

6-inch and 8-inch meters = 3-inch bypass

- B. Existing Services.** Where existing water services are indicated on the Drawings to be replaced, relocated, or reconnected to new water lines, the CONTRACTOR shall make prior arrangements with each water customer as to the time and length of shutdown necessary. The customer shall be notified 24 hours before any connections are made. A maximum shut-off time of four (4) hours will be allowed for making connections, after which time the CONTRACTOR shall supply the customer with potable water from an approved source, at no additional cost to the Utility.
- C. Metallic Tracer Tape.** For 3-inch services and larger (i.e. PVC), width shall be a minimum of 6-inches or twice the line diameter. The burial depth shall not exceed 36-inches below final grade nor be at an elevation of less than 12-inches above the utility line. Recommended burial depth shall be according to the tape manufacturer.

Color of tape shall conform to American Public Works Association (APWA) color code. Acceptable manufacturer shall be THOR Enterprises, Inc., “Magnelec” or equivalent as approved.

- D. Meter Box Installation.** Meter boxes shall be installed in accordance with these specifications and Utility Standard Details. Install to grade matching top of curb.

Meter boxes shall not be installed under sidewalks, driveways, or proposed above-ground structures. Where no curbing exists, install boxes in accessible locations beyond limits of street surfacing, walks, and driveways.

The following standard meter boxes shall be installed for their respective meter size, unless otherwise determined and approved by the Utility.

STANDARD METER BOXES			
METER SIZE	BOX TYPE	CONSTRUCTION	DIMENSIONS W x H
3/4-inch	Type A	Single Unit	19.25 in. O.D. x 17 in.
1 inch	Type B	Single Unit	26 in. O.D. x 17 in.
1-1/2 in. to 2 in.	Type C	Single Unit	50 in. SQ x 24 in.
3 in. and larger	Type D	Modular	7 ft.-8 in. SQ x 4 ft.-6 in.

Where it is necessary to install Type A or B boxes for 3/4-inch or 1-inch meters under roadways or traffic bearing surfaces, boxes shall be encased in 12-inches concrete 3,000 psi minimum.

- E. Testing and Flushing Procedures.** All services shall be pressure tested for leakage by opening the corporation or service valve at the main service connection point, maintaining the meter angle valve closed, and visually observing all connections and piping for leaks. If no leaks are observed, the service line shall then be flushed as follows. The angle valve is opened to “full” and then the corporation valve is slowly opened to full capacity. Water is allowed to flow until piping has been thoroughly flushed. Then the angle valve is slowly closed to prevent water hammer or shock pressure, which might rupture the main or adjacent water service connections. If no customer piping is currently connected to the meter outlet connection, a fitted plug shall be used at the end of this connection to prevent the entrance of dirt or muddy water.

4. Measurement.

- A. Water Service Replace and Reconnect.** This Item will be measured in place by each water service replaced and reconnected for the size and type indicated.
- B. New Water Service Installation.** This Item will be measured in place by each new service installed for the size and type indicated.

- C. **Meter Boxes.** This Item will be subsidiary to the “Water Service Replace and Reconnect” or “New Water Service Installation” Item and will not be measured for individual payment.

5. Payment.

- A. **Water Service Replace and Re-connect.** The work performed and the materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Water Service Replace & Re-connect” of the size and type specified. This price shall be full compensation for furnishing all required materials, including all costs associated with furnishing labor, new materials, equipment, and incidentals to replace and reconnect existing water services of the specific size and type (water service or fire line); coordination; and all appurtenances defined herein to include, but not limited to the following items: concrete meter boxes, all fittings and valves in accordance with EPWU requirements and as indicated on the drawings. CONTRACTOR shall, at his expense, completely restore to its original condition, any disturbed area associated with the replacement and reconnection of existing water services.
- B. **New Water Service Installation.** The work performed and the materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “New Water Service Installation” of the size and type specified. This price shall be full compensation for furnishing all required materials, including all costs associated with furnishing labor, new materials, equipment, and incidentals to install new water services of the specific size and type (water service or fire line); coordination; and all appurtenances defined herein to include, but not limited to the following items: concrete meter boxes and vaults, all fittings and valves in accordance with EPWU requirements and as indicated on the drawings. CONTRACTOR shall, at his expense, completely restore to its original condition, any disturbed area associated with the installation of new water services.
- C. **Meter Boxes.** The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be subsidiary to the “Water Service Replace & Re-connect” or “New Water Service Installation”.

VII. FIRE HYDRANTS

1. Description.

Scope. Furnish labor, materials, equipment and incidentals to furnish and install fire hydrants as indicated on the drawings, in accordance with Utility requirements and according to typical fire hydrant installation.

2. Materials.

A. Submittals. Submittals shall include certified drawing showing dimensions and construction details and certification from manufacturers that the products comply with appropriate AWWA Standards and these Specifications. Catalog data illustrating equipment to be furnished and a schedule of parts and materials shall be submitted.

Friction loss shall be guaranteed by the manufacturer to meet the requirements of AWWA C-502.

B. Standards. Fire hydrants shall comply with requirements of AWWA C-502, Dry-Barrel Fire Hydrants, and AWWA C-550, Protective Epoxy Interior Coatings for Valves and Hydrants.

C. Manufactured Products.

General. Fire hydrants shall be dry-barrel compression type, with the main valve opening against the pressure, in accordance with AWWA C-502. The hydrant shall be designed for a minimum working pressure of 150 psi and tested at 300 psi hydrostatic pressure.

Hydrant shall have permanent markings identifying name of manufacturer, size of main valve opening and year of manufacture. Markings shall be easily located and legible after the hydrant has been installed.

Hydrants shall be constructed so that the standpipe may be rotated to eight (8) different positions.

Center of the lowest nozzle shall have a minimum ground clearance of 15-inches. Hydrants shall be supplied with extension sections in multiples of 6-inches with rod and coupling as required to increase barrel length.

The fire hydrant manufacturer shall provide local representation and support services, through an established vendor, within the County of El Paso. Acceptable manufacturers and models shall be:

American Flow Control	B84B
Clow	Medallion
Kennedy	Guardian K81A
M&H	Style 129
Mueller	Centurion

Size. Minimum inside barrel diameter shall be 7-inches. Minimum diameter of the main valve opening shall be 5-inches.

Traffic Type. The barrel and operating mechanism shall be so designed that in the event of an accident, damage, or breaking of the hydrant above or near the grade level, the main valve will remain closed and reasonably tight against leakage.

Manufacturer shall guarantee that the hydrant valve stem will not be bent when the hydrant is damaged or broken at or near ground level. A safety breaking flange or thimble shall be provided. Provisions shall be made in the design of the stem to disconnect the stem from the hydrant parts above the standpipe break point in the event of a traffic accident.

If breakable couplings are used, the design shall be such that the barrel safety flange and stem safety collar will break before any other hydrant part in the event of an accident. Design of coupling shall be such that no part of the coupling will drop into the hydrant barrel in the event of an accident.

Drain Outlet. Upper valve plate, seat ring and drain ring or shoe bushing shall be bronze, to form an all bronze drain way. The drain valve shall be provided to drain the hydrant properly by opening as soon as the main valve is closed.

Inlet Connections. Shall be mechanical joint, with accessories, gland, bolts, gaskets, and a 6-inch diameter inlet connection. Main valve facing against seats shall be synthetic rubber. Top of the stem or bonnet shall be equipped with O-ring seal. Hydrant shall be oil or grease lubricated.

Outlet and Pumper Nozzles. There shall be two hose outlets with two 1/2-inch nozzles with National Standard hose coupling screw threads. The outlet nozzles shall be of the caulked type or mechanically connected into the barrel with an O-ring seal and a non-corrosive locking pin to lock the nozzle to the barrel.

Pumper Nozzle shall have an inner diameter of 4-inches with threads conforming to the City of El Paso Standards.

Nozzle caps shall have one 1-inch square nut, gaskets and non-kinking chains. The operating nut and nozzle cap nuts shall be one 1-inch square at the base and tapered to 7/8-inch square at the end and not less than 1-inch deep. Nozzle caps to be provided with rubber gaskets.

Hydrant Operator. Shall be 1-inch square at the base and tapered to 7/8-inch at the end and not less than 1-inch deep. Attachment of the operator nut shall not, in any way, hinder operating the hydrant with the wrench. The hydrant operator shall open by turning left (counterclockwise).

Hydrants shall be designed with O-ring seals to prevent water from damaging the operating threads.

Tamper Proof Cover. The hydrant shall be equipped with a tamper proof cover, with drainage holes, that deters unauthorized operation of the hydrant.

The tamper proof cover shall provide adequate wrench clearance and shall have a minimum inside diameter of 2-1/4". The height of the cover shall range from 2-1/4" to 2-1/2", measured from the base at the bonnet to the top of the collar.

Painting. Barrels above ground shall be prime-coated and painted with two coats of paint, color shall be "aluminum" as approved by the Water Utility.

Protective Coating. All interior ferrous surfaces of shoe exposed to flow shall be epoxy coated to a minimum dry thickness of 4 mils. Epoxy coating shall be factory applied by an electrostatic or thermosetting process in accordance with manufacturer's printed instructions. Epoxy materials shall be 100 percent powder epoxy or liquid epoxy conforming to AWWA C-550 and to the current requirements of the Food and Drug Administration and the EPA for potable water.

3. **Execution.** Hydrants shall be installed in locations as shown on the Drawings or in standard locations approved by the Water Utility. Installation shall conform to typical details of the Water Utility. Paint damaged during installation shall be touched up. Hydrants shall be disinfected with the connecting pipe in accordance with Article VIII "Cleaning, Disinfection and Testing of Water System" in these Specifications. All hydrants shall be furnished and left in good working order with control valve open.

4. Measurement.

- A. **Fire Hydrant (Relocate & Reconnect).** This Item will be measured in place by each fire hydrant reconnected to the new or existing water main.
- B. **Fire Hydrant (New).** This Item will be measured in place by each new fire hydrant connected to the new water main.

5. Payment.

- A. **Fire Hydrant (Relocate & Reconnect).** The work performed and the materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Fire Hydrant (Reconnect Only)" as specified. This price shall be full compensation for furnishing all required materials, including new piping from the new or existing water main to the fire hydrant, new gate valve with bonnet box, concrete thrust blocking or mechanical joint restraints, new spool extensions as needed, new fittings and appurtenances for a complete installation as shown in the drawings.
- B. **Fire Hydrant (New).** The work performed and the materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Fire Hydrant (New)" as specified. This price shall be full compensation for furnishing all required materials, installation of new fire hydrant, spool extensions as needed, mechanical joint tee at the main, gate valve with bonnet box and lid, all PVC C900 pipe from the main to the fire hydrant, thrust blocking or mechanical joint restrainers and all fittings and appurtenances for a complete installation as shown in the drawings.

VIII. CLEANING, DISINFECTION, AND TESTING OF WATER SYSTEM

1. **Description.** This Item shall govern for disinfection and testing of all water mains and related appurtenances.

2. **Materials.**

A. **Standards.** Disinfecting and Testing of Water Mains shall comply with applicable requirements of the following:

AWWA B-300 "Standard for Hypochlorites"

AWWA B-301 "Standard for Liquid Chlorine"

AWWA C-651 "Standard for Disinfecting Water Mains"

B. **Materials.**

1. **Water** required for filling, flushing and testing the line will be provided at the CONTRACTOR's cost, at such points along the pipeline as water is available from the existing distribution or supply systems (See "Water for Construction" in Project General Notes). Wasting of water will not be condoned and such actions may require the ENGINEER to make appropriate charges for such water.

The CONTRACTOR shall make provisions to provide the water, by tank truck or other means, to the points necessary to produce specified test pressure.

The CONTRACTOR shall coordinate the disposal of water with the ENGINEER and El Paso Water Utilities Operations Division. Disposal of water onto the streets will not be allowed and will be considered "wasting of water", unless otherwise approved by the El Paso Water Utilities.

2. **Chlorinating Material.** Shall be either liquid chlorine conforming to AWWA B-301 or hypochlorite conforming to AWWA B-300.

3. **Execution.**

A. **General.** After completion of all pipe line section, the following procedure will be used to clean, sterilize and pressure test the pipeline. The pipeline shall be filled and flushed until all evidence of dirt or debris has been washed from the pipeline. The line shall then be refilled if necessary, introducing the chlorinating material. Each valved section shall then be brought up to test pressure and the leakage test performed. After all sections have been approved, all valves shall be cleaned and the line left full of sterilizing water.

Water for disinfection and testing of water mains will be provided at the CONTRACTOR's expense, as described in "Water for Construction" in Project General Notes.

- B. Quality Assurance.** The CONTRACTOR shall take special care to keep the interior of the pipe clean during storing, handling, and laying operations in order to reduce the need for flushing to an absolute minimum.

In addition, all open ends shall be tightly covered whenever unattended to prevent small animals and dirt from entering the pipeline after it is in place.

- C. Sterilization.** Before acceptance for operation, each unit of completed water system shall be sterilized as specified below or as prescribed by AWWA Standard C-651. (As per C-651, two consecutive sets of acceptable samples taken at least 24 hours apart, shall be collected from the new main.) The unit to be sterilized shall be thoroughly flushed with water until all entrained dirt and mud have been removed before introducing the chlorinating material. The CONTRACTOR shall provide all chlorination material for sterilization at his cost. The chlorinating material shall provide a dosage of not less than 50 parts per million and shall be introduced into the water line in an approved manner. The treated water shall be retained in the pipe long enough to destroy all nonspore-forming bacteria. Except where a shorter period is approved, the retention time shall be at least 25 hours and shall produce not less than 10 ppm of chlorine at the extreme end of the line at the end of the retention period.

All valves on the lines being sterilized shall be opened and closed several times during the contact period.

- D. Hydrostatic Pressure and Leakage Testing.** All valves and hydrants shall be checked for proper operation and pressure the pipe system shall be subjected to a hydrostatic pressure and leakage test. After completion of each valved section and following the filling and disinfection of the section, the system shall be subjected to this test. The meter, pressure gauges, pump, small piping and hose connections, and all labor necessary for conducting the test, shall be furnished by the CONTRACTOR.

After the section of pipeline has been filled, water shall be pumped into the section and the pressure raised to 150 psi. This test pressure shall be maintained for a period of at least two (2) hours. The water required to maintain this pressure shall be delivered into the pipe through the meter. The amount of water through the meter during the two-hour test period will be the total leakage. Should this leakage exceed the allowable amount, as specified herein, the CONTRACTOR shall make such repairs as may be required until the actual leakage, as determined by succeeding tests, is no greater than the allowable as determined by the following formula:

$$L = S \times D \times (P^{1/2}) / 133,200$$

except that $L = 0$ in above ground systems and otherwise

L = Allowable Leakage in gallons/hour

S = Length of pipe tested in feet

D = Nominal diameter of pipe in inches

P = Average test pressure during the test, in pounds per square inch, gage; determined by computing the weighted average of actual pressures on various portions of the section.

After all sections of the pipeline have been tested, as described above, all valves shall be closed and the line left filled with the water to be used for disinfection and testing.

4. **Measurement.** This Item is subsidiary to the various water mains and related appurtenances Items in this Contract. This Item will not be measured for individual payment.

Payment. The work performed and the materials furnished in accordance with this Item and measured as provided under "Measurement" will not be paid individually as it is subsidiary to the various water mains and related appurtenances.

IX. SANITARY SEWER FACILITIES

1. **Description.** This Item shall govern for all materials and work necessary for the installation of sanitary sewer construction and adjustments in conformity with the details shown on the plans and as described herein.

A. Verification of Utilities. The data furnished in the plans regarding the size and location of utility lines has been obtained from field surveys and the various utility companies. The CONTRACTOR is responsible for verifying the location of all utilities prior to commencing sewer construction. All work shall be within public right-of-way and at no time shall extend into or encroach upon private property including basements, residences, and places of business.

B. Coordination with El Paso Water Utilities (EPWU). Coordination with EPWU is required for sewer line tie-ins and bypassing, where indicated in the specifications and on the plans, and for CCTV video-inspection of new sewer lines. EPWU will perform video-inspection of all new sewer lines to determine acceptance. CONTRACTOR shall notify EPWU a minimum of 48 hours in advance of any scheduled inspection; and CONTRACTOR shall provide a staging area free and accessible for TV camera activities.

C. Water Main Crossing. Where gravity or force main sewers are constructed in the vicinity of water mains, the most current requirements of the Texas Commission on Environmental Quality (TCEQ) shall be met.

2. Materials.

A. Polyvinyl Chloride (PVC) Flexible Pipe.

1. **Scope.** These standard specifications designate the requirements for the furnishing and installation of PVC (polyvinyl chloride) gravity pipe for sanitary sewage, with a standard dimension ratio (SDR) as shown in the drawings and/or specified herein. The CONTRACTOR shall furnish all materials, equipment, tools, labor, superintendence, and incidentals required for the complete construction of the work designated.

2. **Quality Assurance.** All PVC pipe shall be coded to provide positive identification and prevent accidental damage to or interruption of the sanitary sewer facilities.

Only pipe manufactured in the United States of America will be accepted. All pipe, fittings, and accessories shall be new. Manufacturer's physical and chemical tests shall be performed according to the ASTM standard applicable to the respective PVC pipe type and diameter herein specified, in order to demonstrate pipe quality.

3. **Submittals.** Submit documentation on pipe products, fittings, and related materials as may be required by the Contract Documents or the Engineer. Review all submittals prior to submission. Submit in a timely manner so as not to delay the project. Allow sufficient time for ENGINEER's review and resubmission, if necessary. Include certifications from manufacturer that the product complies with appropriate ASTM standards.

4. Standards. PVC pipe shall comply with applicable requirements of the following:

ASTM D-1784	Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
ASTM D-2321	Specification for Underground Installation of Flexible Thermoplastic Sewer Pipe
ASTM D-3034	Specification for Type PSM Poly (Vinyl Chloride) (PVC) Large Diameter Plastic Gravity Sewer Pipe and Fittings
ASTM D-3212	Joints for Drain and Sewer Pipes Using Flexible Elastomeric Seals
ASTM F-477	Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F-679	Specification for Poly (Vinyl Chloride) (PVC) Large Diameter Plastic Gravity Sewer Pipe and Fittings
ASTM F-789	Specification for Type PS-46 Poly (Vinyl Chloride) (PVC) Plastic Gravity Flow Sewer Pipe and Fittings
ASTM F-794	Specification for Poly (Vinyl Chloride) (PVC) Large Diameter Ribbed Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter

5. Delivery and Storage. Pipe, fittings, and accessories shall be inspected upon delivery and during progress of the work. Any material found defective will be rejected by the ENGINEER, and shall be promptly removed from site.

CONTRACTOR shall be responsible for all material furnished by him and shall replace, at his own expense, any material found to be defective in manufacture or damaged.

All pipe, fittings, and other accessories shall, unless otherwise directed, be unloaded at point of delivery, hauled to and distributed at the site of the work by the CONTRACTOR. In loading and unloading, materials shall be lifted by hoists or rolled on skidways so as to avoid shock or damage. Under no circumstances shall materials which have been dropped be incorporated in the work. Pipe handled on skidways shall not be skidded or rolled against pipe already on the ground.

PVC pipe shall not be stored outside exposed to prolonged periods of sunlight. Discoloration of pipe due to such exposure is an indication of reduced pipe strength and may be sufficient cause for rejection of the pipe. Any pipe rejected shall be removed from the job site.

6. Pipe Schedule. Polyvinyl Chloride (PVC) pipe shall be designated as gravity sewer conduit and shall meet the requirements as set forth in the following schedule in the various diameters and types shown:

PIPE SIZE	ASTM STANDARD	MATERIAL	WALL TYPE	MINIMUM STIFFNESS	STANDARD LENGTH
8"	D-3034	PVC	SOLID SDR-35	46 psi	20'
12" 15"	F-789	PVC	SOLID T1-WALL	46 psi	20'
18"	F-679	PVC	SOLID T1-WALL	46 psi	20'
	F-789	PVC	SOLID T1-WALL	46 psi	20'
	F-794	LARGE DIA PVC	PROFILE OPEN	46 psi	13'
21"- 27"	F-679	PVC	SOLID T1-WALL	46 psi	20'
	F-794	LARGE DIA PVC	PROFILE OPEN OR CLOSED	46 psi	13'
30"- 36"	F-794	LARGE DIA PVC	PROFILE OPEN OR CLOSED	46 psi	13'
39"- 60"	F-794	LARGE DIA PVC	PROFILE CLOSED	46 psi	13'

Pipe shall be furnished in the standard lengths shown although not more than 15 percent may be in random lengths.

7. **Joints.** Joints shall be push-on, bell and spigot type, with elastomeric seals and conform to the requirements of ASTM D-3212. Gaskets shall be factory installed and chemically bonded to the bell end of the pipe. Gasket material shall conform to the requirements of ASTM F-477.
8. **Pipe Materials.** Pipe and fittings shall be made from polyvinyl chloride compounds which comply with the requirements for minimum cell classification defined by ASTM D-1784. Fittings, service risers, and laterals shall be PVC with a SDR 35 rating.
9. **Pipe Trenching, Installation and Backfill.** Except as noted, Pipe Trenching, Installation and Backfill of PVC gravity sewer pipe shall be in accordance with ASTM D-2321 and Article IV of these Specifications.

Trench Width: Trench width shall be as specified for FLEXIBLE PIPE in Article IV, Section 3, of these Specifications.

Pipe Installation: Following the preparation of the trench bottom and trench bracing installed where required, pipe laying shall generally proceed upgrade with spigot ends pointing downgrade.

Pipe shall be laid true to lines and grades as indicated on the drawings. Grade may be established by laser beam, or batter boards (not exceeding 50 foot intervals), and string line may be used with each pipe set to grade, from the string line, with a grade rod equipped with a "shoe" designed to fit into the flow line of the pipe.

- 10. Testing.** PVC shall be inspected, tested for leakage and deflection in accordance with SECTION 3.C of this Article.

B. Ductile Iron Pipe.

- 1. Scope.** Furnish all labor, materials, equipment and incidentals required and install all ductile iron piping, as shown on the drawings and as specified herein.
- 2. Quality Assurance.** Manufacturer shall have a minimum of ten years successful experience in designing and manufacturing DIP of the type specified. The entire pipeline shall be the product of one manufacturer. The manufacturer shall have a minimum of ten years successful experience in designing and manufacturing pipe joints of similar design, pipe diameter, and pressure class as those specified. Pipe shall conform to American National Standards Institute/National Sanitation Foundation (ANSI/NSF) Standard 61 "Drinking Water System Components - Health Effects" and be certified by and organization accredited by ANSI. Such compliance shall be evidenced by an affidavit from the manufacturer or vendor. If the pipe does not presently conform to this standard, information from the manufacturer regarding action being taken to comply with this standard must be submitted.
- 3. Submittals.** Submit documentation on pipe products, fittings, and related materials as may be required by the Contract Documents or the ENGINEER. Review all submittals prior to submission. Submit in a timely manner so as not to delay the project. Allow sufficient time for ENGINEER's review and resubmission, if necessary. Include certifications from manufacturer that the Ductile Iron Pipe complies with appropriate AWWA Standards and ANSI/NSF Standard 61.

Such compliance shall be evidenced by an affidavit from the manufacturer or vendor. If the pipe does not presently conform to this standard, information from the manufacturer regarding action being taken to comply with this standard must be submitted.

If requested, copies of results of factory hydrostatic tests shall be provided.

- 4. Standards.** DIP shall comply with applicable requirements of the following:

ASTM A-746	Specification for Ductile Iron Gravity Sewer Pipe
AWWA C-104	Standard for Cement Mortar Lining for Ductile Iron Pipe and Fittings
AWWA C-105	Standard for Polyethylene Encasement for Ductile Iron Piping
AWWA C-110	Standard for Ductile Iron and Gray Iron Fittings

AWWA C-111 Standard for Rubber Gasket Joints for Ductile Iron Pipe and Fittings

AWWA C-150 Standard for Thickness Design of Ductile Iron Pipe

AWWA C-151 Standard for Ductile Iron Pipe

- 5. Pipe Materials.** Ductile iron pipe shall be manufactured in accordance with AWWA C-151. The minimum pressure class rating shall be 150 psi, unless otherwise specified. The Ductile Iron shall conform to ASTM Specification A-746 with physical properties of Grade 60-40-18. The pipe shall be designed for five (5) feet of cover or for the depths shown on the plans, whichever is greater. Standard joint length shall be 18 or 20 feet and inside diameter shall be industry standard.

CONTRACTOR shall be responsible for all material furnished by him and shall replace, at his own expense, any material found to be defective in manufacture or damaged.

- 6. Joints.** Shall be in accordance with AWWA C-111, AWWA C-151. Standard joints for ductile iron pipe shall be push-on. Where indicated on the drawings, joints shall be mechanical or flanged. Flanged joints shall have pressure ratings equal to or greater than adjacent pipe. Flange pattern shall match pattern of valve, fitting, or appurtenance to be attached.
- 7. Fittings.** Shall be ductile iron in accordance with AWWA C-110 and Article V of these Specifications. Fittings shall be rated for a minimum working pressure of 250 psi, unless otherwise specified.

Factory welded outlets, minimum pressure rating 250 psi, may be used in lieu of tee fittings for 18-inches and larger tee fittings. Factory welded outlets may not be used near sources of vibration, such as pump stations or roads, unless specifically noted on the plans.

- 8. Exterior Coating.** The manufacturer shall provide a standard asphaltic coating in accordance with AWWA C-151, unless otherwise specified. The finished coating shall be continuous, and smooth and strongly adherent to the pipe.

Polyethylene wrap shall be used on ductile iron for sizes 30-inches and smaller. The polyethylene wrap shall be applied in accordance with AWWA C-105/A21.5 except a minimum thickness of 30 mils shall be used.

Tape coating shall be used for pipe sizes 36-inch and larger where specified. The exterior of the pipe shall have a prefabricated cold-applied tape coating system conforming to the requirements of ANSI/AWWA C-214, except as noted herein. The surface shall be blast cleaned to achieve a surface preparation at least equal to that specified in SSPC SP6. The blast profile shall have an anchor pattern as specified by the tape manufacturer. The coating shall be held back from the end of the pipe the minimum distance recommended by the pipe manufacturer for the type of joint used. Tape wrap cut back shall be tapered. Nominal thickness shall be 80 mils.

- 9. Interior Lining.** Ductile Iron Pipe and fittings shall have an epoxy lining in accordance with ASTM D714. Epoxy lining shall be appropriate for wastewater pipe application. Lining thickness shall be 40-mils (min.).
- 10. Provisions For Thrust.** Where indicated and where required for thrust restraint, joints shall be restrained. Restrained joints shall be mechanically interlocking joints. Restrained joints shall be U.S. Pipe "TR Flex", American Cast Iron Pipe "Flex Ring", or Clow Corporation "Super-Lock". Restrained joints shall be capable of sustaining the specified design pressure. If thrust cannot be accommodated using restrained joints, such as bends adjacent to casing pipe, use approved thrust restraint devices.

Thrust at bends, tees, plugs, or other fittings shall be resisted using thrust restraint devices. Concrete thrust blocks are not allowed unless approved by the ENGINEER. Acceptable thrust restraint devices shall be as manufactured by EBAA Iron, Ford Uni-Flange, or approved equal.

NOTE: At connection of new sewer force main to existing main, both concrete thrust blocking (per Article II of these Specifications) and thrust restraint devices must be used.

Restrained joints shall be used for a sufficient distance from each bend, tee, plug, or other fitting to resist thrust which will be developed at the design pressure of the pipe. For the purposes of thrust restraint, design pressure shall be 1.5 times the design working pressure class indicated. Length of pipe with restrained joints to resist thrust forces shall be determined by pipe manufacturer in accordance with the Handbook of Ductile Iron Pipe. The following parameters shall be used: laying condition equal to AWWA C-600 Type 5 soil, safety factor of 1.8, a unit bearing resistance equal to zero, an a factor for polyethylene encasement as recommended by DIPRA, if required.

- 11. Pipe Trenching, Installation, And Backfill:** Except as noted, Pipe Trenching, Installation, and Backfill for DIP shall be in accordance with AWWA C-600 and Article IV of these Specifications.

General: Any damage to Polyethylene wrap shall be repaired according to AWWA C-105. Pipe shall be kept clean during installation. Exposed ferrous metal which cannot be protected with field-applied tape coating, shall receive two coats of Koppers Bitumastic No. 50, or approved equal.

Pipe and fittings shall be installed to line and grade indicated. In areas where the line and grades indicated cannot be achieved using standard manufactured bends and fittings, make slight adjustments by deflecting joints according to the limitations of AWWA C-600.

Pipe Zone Embedment: Unless otherwise specified, Ductile Iron Pipe shall be embedded in Class II material as defined in Article IV, Section 3.C. Native material or imported material meeting or exceeding Class II requirements may be used. Class I material may be acceptable only in groundwater conditions if approved by the ENGINEER.

Pipe Cutting: When required, the cutting shall be by machine, leaving a smooth cut at right angles to the axis of the pipe. Ends of cut pipe to be used with a push-on joint bell shall be beveled to comply with manufactured spigot end. Cement lining shall be undamaged.

Corrosion Protection: As a precaution against corrosion, all flanges, bolts, nuts and other exposed metal surfaces underground shall be coated with Texaco, Koppers, or equal rustproof compound.

- 12. Testing.** Disinfect and test the piping system in accordance with Section 3.C of this Article and as detailed in AWWA C-651.

3. Sanitary Sewer System.

A. Sewer Service Connections.

- 1. Scope.** Furnish labor, materials, equipment and incidentals to install sewer service lines as indicated on the plans, in accordance with EPWU Standards.
- 2. Materials.** Fittings, service risers, and laterals shall be as specified for the material type utilized. Where additional service connections are required on an existing main line, an approved service saddle compatible to the size and type of both the collection line and service lateral shall be installed.

All sanitary sewer services shall be of materials conforming to the requirements of the City of El Paso's Plumbing Code and all amendments thereto.

Where PVC saddles with rubber seals and stainless steel bands are used, the saddles shall be encased with Class B (2500 psi) concrete in accordance with EPWU Standards to protect the steel bands from corrosion and to add stability.

- 3. Tees and Riser.** Where designated on the plans or directed by the ENGINEER in the field, CONTRACTOR shall install tee or wye fittings for future house service connections. Fittings shall be bell-type and shall be sealed on the branch outlet with an approved plug which can be easily removed for service riser or lateral line installation.

Where ground water is encountered, the CONTRACTOR shall install the tee and a sufficient service line RISER, thereby raising the final bell above the ground water level. In deep trenches, the RISER shall be extended to the depth of the intersecting service line, or to within 6 feet of the surface, whichever is designated by the plans or appropriate for field conditions.

CONTRACTOR shall install a maximum of four (4) service connections at manholes located at the ends of street cul-de-sacs. Additional services shall connect to the main line at a minimum spacing 24-inches.

- 4. Service Connections and Laterals.** Where required by the Contract drawings and specifications, the CONTRACTOR is to provide new sewer service laterals and re-connections of all existing sewer service laterals to new lines installed to replace lines to be abandoned.

The CONTRACTOR shall be responsible for verifying location of laterals indicated on the drawings and ensuring service is not interrupted to homes or other establishments. Wyes, bends, tees, stacks, and other hardware where required, shall be installed for service laterals as shown in the plans or as directed by the ENGINEER. Unless otherwise specified, the minimum diameter of the lateral service lines shall be 4 inches. Although the maintenance of service laterals is the responsibility of private property owners, including the portion within public right-of-way, as established by Public Service Board Rules and Regulations, the CONTRACTOR shall be responsible for the integrity of the installation or re-connection of all such service lines during the warranty period. All sanitary sewer services shall be of materials conforming to the requirements of the City of El Paso's Plumbing Code and all amendments thereto.

Connections between new work and existing work, where required, shall be made using proper specials and fittings to suit the actual conditions. When it is necessary to interrupt service to existing facilities in order to make connection to an existing line, the CONTRACTOR may be required to make the connections at some time other than during normal working hours at no additional costs to the Utility.

Unless otherwise specified or shown in the drawings, new service lines shall be installed and extended 6 inches beyond existing or proposed improvements such as pavement, curb and gutter, sidewalk, etc. Service lines shall be installed at a minimum slope of 2 percent with a minimum cover at the terminus of 18-inches for standard subdivisions having curb and gutter for drainage. For subdivisions with flat terrain and on-site ponding (no curb and gutter), minimum cover shall be 3.5 feet, unless otherwise directed by the ENGINEER. Prior to installation, Utility personnel will curb mark the locations of proposed service tees for the CONTRACTOR. Service lines and/or tees shall be laid such that the branch makes an angle of 45° with the vertical on the side of the main facing the lot to be served.

Service pipe shall be uniformly supported on bedding having a density of not less than 90 percent of maximum density per ASTM D-1557. Backfill on service lines shall be carefully placed and compacted per the requirements of Article IV, Section 3.D of these Specifications. The terminus of the service line shall be plugged with an approved universal end cap compatible with the pipe size and material.

All service risers and lateral extensions shall be installed by a qualified licensed plumber who shall be bonded and approved by the City Public Inspection Department. CONTRACTOR shall provide evidence to the ENGINEER that the Plumber is licensed and insured in accordance with the requirements of the City of El Paso.

- 5. Location Marking and Recording.** The CONTRACTOR shall maintain as-built records of the horizontal and vertical location of installed sewer service lines. In unpaved areas without curb, the plugged ends of risers or laterals shall be marked using a 1" by 2" by 24" wooden stake set vertically at the plugged terminus, and a sufficient length of plastic metallic marking tape extended vertically from the

terminus to within 6-inches of ground surface. An electronic marker disk may be used in lieu of metallic tape. Utility personnel will mark locations of the installed service line or riser ends by chipping an arrowhead mark on top of the curb directly over the service plug.

B. Manhole Structures.

- 1. Scope.** CONTRACTOR shall furnish all labor, materials, equipment and incidentals necessary to provide all manholes as required.

Manholes for the various sized lines shall be Standard Type "A" (48-inch inside diameter), Type "B" (72-inch inside diameter), or Drop Manhole constructed at the locations designated, and in accordance with Utility Standard Details, and as otherwise indicated in the project drawings.

Manholes shall be constructed pre-cast concrete sections, as herein specified.

- 2. Quality Assurance.** All manholes shall be free of visible leakage. Each structure shall be tested for leaks and inspected, and all leaks shall be repaired in a manner subject to ENGINEER's approval.
- 3. Submittals.** Complete manufacturer's shop drawings on the manhole section(s), to include the joints, shall be submitted for approval. If the shop drawings do not meet specifications and secure the ENGINEER's approval, the vendor shall revise their shop drawings to meet specifications and receive ENGINEER's approval. Manufacturer's specification data and recommendations shall be submitted on the lifters and joint material.

Compliance with ASTM C-478 and these Specifications shall also be submitted. Failure to provide either the detailed shop drawings, specification data and recommendation on lifters and joint material, or the letter certifying that all material provided shall meet specifications shall be grounds for rejection of the material.

- 4. Standards.** Manhole structures shall comply with applicable requirements of the following:

ASTM A-48	Specification for Gray Iron Castings
ASTM A-82	Specification for Steel Wire, Plain, for Concrete Reinforcement
ASTM A-185	Specification for Steel Welded Wire, Fabric, Plain, for Concrete Reinforcement
ASTM A-615	Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM C-32	Specification for Sewer and Manhole Brick (Made from Clay or Shale)
ASTM C-33	Specification for Concrete Aggregates
ASTM C-144	Specification for Aggregate for Masonry Mortar

ASTM C-150 Specification for Portland Cement

ASTM C-309 Specification for Liquid Membrane-Forming Compounds for Curing Concrete

ASTM C-478 Specification for Pre-cast Reinforced Concrete Manhole Sections

ASTM C-923 Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures and Pipes

ASTM D-1557 Test Methods for Moisture-Density Relations of Soils and Soil Aggregate Mixtures Using 10-lb (4.54-kg) Rammer and 18-in (457-mm) Drop

- 5. Materials.** Frame and Cover: The manhole frame and cover shall be of cast iron of the weight, dimensions, and pattern indicated by the Utility Standard Details. The casting shall be made from superior quality, gray cast iron conforming to the requirements of ASTM A-48. No holes shall be in the cover, but edge notches for embedded rings shall be used for lifting. "SEWER" or a suitable designation is to be on the cover. Mating surfaces shall be machined to assure a snug fit of the cover and frame.

Manhole Rings: Manhole rings used for a maximum 2-foot final grade shall conform to the applicable requirements of ASTM Specifications C-32, Grade MS.

Cement: Cement shall be Portland Cement conforming to ASTM Specifications C-150, Type V.

Mortar Sand: Mortar sand shall conform to ASTM Specifications C-144.

Concrete Aggregates: Concrete aggregates shall conform to ASTM Specifications C-33 except that the requirement for gradation shall not apply to concrete manhole conical and riser sections.

Steel Reinforcement: Billet-steel bars shall conform to ASTM Specifications A-615 and welded steel wire fabric shall conform to ASTM Specifications A-82 or to ASTM Specifications A-185.

Water: Water shall be clean, clear, free from oil, acid or organic matter and injurious amounts of alkali, salts or other chemicals or deleterious materials.

Mortar: Mortar shall be composed of 1 part Portland Cement Type V and 3 parts mortar sand mixed in an approved manner with water to form a workable mixture.

- 6. Pre-Cast Concrete Manholes.** General: The manhole riser and conical section shall be designed for sewer and water installations in the diameters specified or shown. All manhole sections shall have a 5-inch wall thickness with tongue and groove, unless otherwise specified. Rings shall be available in various lengths from one foot to four feet. The conical sections shall be concentric and adapted to the ring at one end and to El Paso Water Utilities standard cast iron frame at the other. The base ring shall have a flat bottom joint. Steps or rungs are not required.

Manufacturing of manhole section(s) shall comply with ASTM C-478 and any additional specifications listed here forth:

Concrete: Concrete to have a minimum 28 days compressive strength of 4000 psi. Water cement ratio shall be 0.5 or less by weight or not more than 5.5 gallons per sack.

Aggregates: All aggregates fine and coarse other than lightweight aggregate shall conform to specifications outlined by ASTM C-33. Aggregates shall be free of deleterious substances causing reactivity with oxidized hydrogen sulfide. Both types of aggregates shall be graded in order to produce a homogeneous concrete mix. All materials are to be accurately weighed at a central batching facility for mixing.

Cement: All cement shall be Portland cement conforming to ASTM C-150, Type V (sulfate resistant) for sewer applications. Cement content shall be sufficient to produce a minimum strength of 4,000 PSI, or other design strengths required.

Placing: All concrete shall be handled from the mixer or transport vehicle to the place of final deposit in a continuous manner, as rapidly as practicable, and without segregation or loss of ingredients, until (the approved unit operation) is completed. Concrete shall be placed in layers not over two feet deep. Each layer shall be compacted by mechanical internal or external vibrating equipment. Duration of the vibration cycle shall be limited to the time necessary to produce satisfactory consolidation without causing objectionable segregation.

Quality Assurance: The ENGINEER reserves the right to inspect the manufacturing process at any time to make tests on materials used, and to have cores cut out of the completed manholes for compressive strength testing and placement of reinforcement.

Curing: For purposes of early re-use of forms, the concrete may be heated in the mold after the initial set has taken place. The temperature shall not exceed 160 degrees and shall be raised from normal ambient temperature at a rate not to exceed 40 degrees per hour. The cured unit shall not be removed from forms until sufficient strength is obtained for the unit to withstand any structural strain that may be subjected during the form stripping operation. After the stripping of forms, further curing by means of water spraying or a membrane curing compound may be used and shall be of a clear or white type, conforming to ASTM C-309-58.

Steel Reinforcement: Reinforcing steel shall be as outlined in ASTM C-478 and any additional specifications herein. The minimum steel area of 0.12 square inches shall apply to both risers and cone sections and the maximum center to center spacing of 6-inches shall apply as well. Placing of reinforcing steel for one line circumferential reinforcement shall be on the tension side of the wall (the inner half part of the wall with a minimum 1-inch cover) for two lines circular reinforcement, refer to ASTM C-478. All reinforcing shall be sufficiently tied to withstand any displacement during the pouring operation.

Joint Reinforcement: Both tongue and groove shall contain a #4 re-bar.

Lifters: Lifters shall be designed to handle the imposed weights, and shall be placed per manufacturer's requirements.

Joint Material: All joints to be sealed using Ram-Nek joint sealer. Joint sealer to be provided in sufficient quantities by the vendor as part of the manhole section(s). Size shall be per manufacturer's recommendations.

7. **Cast-In-Place Concrete Manholes.** In special circumstances, cast-in-place concrete manholes shall be constructed as shown in the plans, and provided the wall thickness is not less than 6-inches, the concrete is of good quality and well vibrated, and the method of construction materials and type of forms to be used are approved by the El Paso Water Utilities.
8. **Manhole Connectors.** At manholes, a water-tight resilient connection shall be made between the wall and the pipe. This shall be accomplished by use of an engineering approved manhole waterstop adaptor such as Indiana Seal Manhole Adaptor, Kor-N-Seal, or approved equal, meeting the requirements of ASTM C-923. The connector must be compatible to both the type of pipe wall and manhole wall, and shall be installed in strict accordance with the recommendations of the connector manufacturer.
9. **Installation.** The manholes shall be constructed at the location shown on the plans or as directed by the ENGINEER and in accordance with the details shown on the plans and as specified herein. After the excavation has been completed, the concrete base or bottom shall be poured.

When the concrete has sufficiently set, the riser work may proceed. After the manhole rise has been completed, the invert shall be neatly formed in the bottom of the manhole with concrete. The invert shall have a true curve of as large a radius as the size of the manhole will permit and shall be given a smooth trowel finish.

The subgrade under pre-cast manhole bases shall be compacted to 95% density in accordance with ASTM D-1557. Compaction limits shall be one foot beyond the perimeter of the concrete base and shall be a minimum of one foot in depth.

Drop connections shall be constructed as shown on the drawings.

All manholes that are in ground water shall be externally coated with a bituminous coating such as Coal Tar Epoxy. Interior coating of manholes shall be required only when specified in the construction plans. The coating shall be an epoxy resin-type material such as Plascite 7122 or approved equal.

C. Inspection and Testing.

1. **Scope.** Test all piping as specified herein unless authorized by the ENGINEER.
2. **Standards.** Inspection and testing sewer lines and manholes shall adhere to requirements of the following:

ASTM C-828 Recommended Practice for Low-Pressure Air Test of Vitrified Clay Pipe Lines (4-12 Inches)

ASTM C-1103	Standard Practice for Joint Testing of Installed Pre-Cast Concrete Pipe Sewer Lines
ASTM D-3034	Specification for Type PSM Poly(Vinyl Chloride)(PVC) Sewer Pipe and Fittings
ASTM F-679	Specification for Poly(Vinyl Chloride)(PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings
UNI-BELL-6	Standards and Practices for Low-Pressure Air Testing of Installed Sewer Pipe
UNI-BELL-9	Polyvinyl Chloride (PVC) Large Diameter Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter (Nominal Pipe Sizes 18-48 Inch)

3. **Manufactured Products.** CONTRACTOR shall provide all testing apparatus including pumps, compressors, hoses, gauges and fittings, mandrels, and other equipment necessary to perform the required tests.
4. **Television Inspection.:** Prior to placing lines into operation, completed sewer lines shall be inspected by Utility personnel with a television camera as a condition of final approval of the installation. The CONTRACTOR shall thoroughly clean and flush all lines and notify the Engineer that the line is ready for television inspection.

Any defects discovered in the pipe or construction methods shall be corrected by the contractor at no additional cost to the Utility. The Owner will pay for the initial TV inspection. Any additional inspection(s) required due to failure of the initial inspection shall be paid for by the CONTRACTOR.

5. **Leakage Testing. General:** To ensure the integrity of the pipe and joints, all sewer lines installed under these specifications shall be tested for leakage using the guidelines established by ASTM C-828 and UNI-BELL B6, and the methods and procedures here forth described.

CONTRACTOR shall provide all testing apparatus including pumps, compressors, hoses, gauges and fittings and other equipment necessary to perform the required tests. Acceptable equipment shall be as manufactured by Cherne Industries Incorporated or approved equal.

Unless otherwise approved, CONTRACTOR shall conduct tests in the presence of the ENGINEER. The ENGINEER shall be notified 48 hours in advance of testing. Test results shall be recorded on standard Utility forms, a copy of which is attached in Appendix Section E of these specifications.

Low pressure air testing may be conducted by the CONTRACTOR or an independent testing firm, acceptable to the Engineer.

Sewer lines shall be tested after the "pipe zone" backfilling is completed, and prior to construction of finished surfacing.

Where house laterals are included as integral part of the project, testing shall be performed on the main and laterals after the risers or laterals have been completed and backfilled.

Pipe shall be thoroughly cleaned prior to conducting leakage tests. Pipelines which exceed the allowable leakage rate shall be repaired and retested at the CONTRACTOR's expense.

All persons conducting an Air Test shall understand fully that an Air Test may be dangerous if conducted improperly.

Exfiltration Air Testing: A Low Pressure Air Test shall be the standard method for testing sewer lines.

Pneumatic plugs shall be sealed tested above ground using a random pipe section pressurized to 5 psig. Plugs should remain intact without bracing or movement out of the section.

Test shall proceed as follows:

Seal off each end of the section of pipe to be tested at a manhole connection. Securely brace test plugs.

Introduce air slowly into the test section through the test plug until an internal pressure of 4.0 psi is reached. Allow internal air temperature to stabilize. Adjust the internal air pressure to 3.5 psi, disconnect the air supply and begin the test.

The section shall maintain the test pressure without losing more than 1.0 psi for a length of time as determined by the following table. If the section being tested includes more than one size of pipe, the test time for each size shall be calculated and added to determine the total test time for the section.

<u>Nominal Pipe Size (d), Inches</u>	<u>Time (t), Minutes/100 Ft.</u>
4	0.3
6	0.7
8	1.2
10	1.5
12	1.8
15	2.1
18	2.4
21	3.0
24	3.6
30	4.8
36	6.0
42	7.3

Any section losing more than 1.0 psi shall be considered to have failed the test, and shall be repaired and re-tested prior to acceptance.

Infiltration Test: Infiltration testing of sewer lines under groundwater shall be mandatory. This test shall be performed prior to initiating any service connections and after backfilling. At testing time, the level of the groundwater shall be over the entire section of the pipe or near its maximum level.

The allowable infiltration for any portion of the sewer system shall be measured by a weir or current meter placed in the appropriate manhole and shall not exceed 50 gallons per inch of internal pipe diameter per mile per day, including manholes.

Suitable plugs or other facilities shall be provided by the CONTRACTOR in order to measure the amount of infiltration. If infiltration is excessive, the CONTRACTOR shall immediately proceed to locate the source of leakage. Once located, the source of leakage shall be sealed by grouting, cementing and rebuilding as required, or by methods approved by the ENGINEER.

Joint Testing: At the direction of the ENGINEER, individual joint testing of pipe larger than 24-inches in diameter shall be performed in accordance with ASTM C-1103 for special conditions not covered by other test methods.

Inspection of Sewer Manholes: Manholes installed under groundwater shall be visually inspected for infiltration leakage through all joints and the manhole base. All leaks or cracks shall be repaired with an approved hydro-cement grout.

- 6. Deflection Testing. General:** As a condition for acceptance of the pipeline, a mandrel test (deflection test) shall be performed by the CONTRACTOR to verify the roundness and proper installation of the flexible pipeline.

Within 30 days, but not less than seven (7) days after the installation and backfilling of the flexible sewer line, including any service connections, the CONTRACTOR shall, in the presence of the ENGINEER, test deflection of the pipe with a mandrel (GO-NOGO device).

Mandrel Fabrication: Mandrels shall be of high quality fabrication and precision as commercially available by Cherne Industries Incorporated, or approved equal. Mandrels shall be approved by the ENGINEER and shall be equipped with proven rings and meet the following requirements:

- a. Mandrel outside diameter (gauge dimension) shall be fabricated to the following specification:

Mandrel O.D. = Pipeline Base I.D. - (% deflection limit x Pipeline Base I.D.) in accordance with ASTM D-3034, F-679, or UNI-BELL-9.

- b. Mandrel Construction: The mandrel design shall be open thereby preventing debris buildup between channels of adjacent fins. The fin sets shall number at least (9) and be removable from the mandrel core. Gauges of various diameters shall be assembled by substituting fin sets of appropriate dimension. The length of the minimum radius portion of the mandrel shall not be less than one-third of the nominal diameter of the pipe being tested.

Execution: Prior to testing, the pipe shall be flushed and cleaned by the CONTRACTOR. Flow shall not be permitted in the pipeline throughout the duration of the deflection test.

The mandrel shall be manually pulled through the pipeline with a suitable rope or cable that is connected to an eyebolt at one end of the gauge. A similar rope or cable shall be attached to the eyebolt at the opposite end of the mandrel and tension shall be applied to it. This will ensure that the mandrel maintains its correct position during testing, while providing easy removal of the mandrel should it become lodged in an excessively deflected pipeline. Winching or other methods of forcing the mandrel through the pipeline shall be unacceptable.

Deflection of a pipeline deflection tested within thirty (30) days of installation shall have a deflection not exceeding 5% of the base inside pipe diameter as established by ASTM Standards D-3034 and F-679 listed in the following table:

Deflection Gauge Dimensions: SDR 35 or RSC 160

Nominal Size	Average I.D.	Base I.D.	5% Deflection Gauge
6"	5.893	5.742	5.46
8"	7.891	7.665	7.28
10"	9.864	9.563	9.08
12"	11.737	11.361	10.79
15"	14.374	13.898	13.20
18"	17.564	16.976	16.13
21"	20.707	20.004	19.00
24"	23.296	22.480	21.36
27"	26.258	25.327	24.06

Pipeline deflection tests performed thirty days (30) beyond the date of installation shall have a deflection not exceeding 7.5% of the nominal inside diameter or as established otherwise by the applicable governing body. Mandrel Gauge shall be adjusted for 7.5% and approved by the ENGINEER. The CONTRACTOR shall make every effort to test for deflection prior to the 30 day expiration.

A permanent record of all testing with locations where excessive pipeline deflections occur shall be kept by the CONTRACTOR and forwarded to the ENGINEER after completion of testing on each line.

The CONTRACTOR shall replace all sections of pipe which deflect more than 5% (or 7-1/2%). Pipelines with acceptable ovality shall be laid such that the larger diameter is situated in the vertical direction.

All expenses for re-trenching, backfill, compaction, paving, and related work necessary due to failure to satisfy deflection test requirements shall be borne by the CONTRACTOR.

4. Sewer Line Bypassing and Draining.

- A. Scope of Work.** This item specifies the requirements for temporary bypassing, draining, flushing and abandonment of sewer lines. The CONTRACTOR shall keep excavations free from water during construction. Disposal of water shall not damage property or create a public nuisance. The CONTRACTOR shall have on hand pumping equipment and machinery in good working condition for emergencies and shall have workers available for its operation.
- B. Requirements.** CONTRACTOR shall provide labor, equipment, materials and supervision to temporarily bypass flow around the CONTRACTOR's work during sewer construction and/or during work associated with sewer construction when necessary. CONTRACTOR shall drain and flush all sewers to be abandoned with a minimum of twice the sewer's volumes of water. CONTRACTOR shall drain all sewers lines to be abandoned. All work shall be closely coordinated with the ENGINEER.
- C. Submittals.** Twenty-one (21) calendar days prior to commencement of construction activities, the CONTRACTOR shall submit to the ENGINEER for review and approval drawings and complete design data showing methods and equipment he proposes to utilize in sewer bypassing and draining. The submittal shall include the following information:
1. Drawings indicating the location of temporary sewer plugs and bypass discharge lines
 2. Schedule times for bypasses
 3. Capacities of pumps, prime movers, and standby equipment
 4. Design calculations proving adequacy of the system and selected equipment
- D. Job Conditions.**
1. **Available Data.** Existing sewer system map of the project area can be obtained from EPWU and are available for review at their office – 1154 Hawkins Blvd., El Paso, TX. 79925, during regular business hours.
 2. **Protection.** Where bypassing or draining of the contents of a line is required, the CONTRACTOR shall ensure that service for connecting sewer laterals are not disrupted. All flow shall be discharged into the nearest downstream manhole and only after consultation with EPWU operations to coordinate the discharge. Bypassing and draining of the contents of a line shall not surcharge sewers or interfere with normal operation of related sewer facilities. No discharging to the ground surface, receiving streams, storm drains, or discharging which results in groundwater contamination or potential health hazards shall be permitted. In the event accidental discharging is caused by the CONTRACTOR's operations, the EPWU shall immediately be entitled to employ others to stop the discharging without giving written notice to the CONTRACTOR.

Penalties imposed on the EPWU as a result of any discharge by the actions of the CONTRACTOR, his employees, or subcontractors, shall be borne in full by the CONTRACTOR, including legal fees and other expenses to the EPWU resulting directly or indirectly from the discharge.

3. **Scheduling.** The bypassing systems shall not be shut down between shifts, on holidays or weekends, or during work stoppages without written permission from the ENGINEER. The CONTRACTOR shall submit a detailed outage plan and time schedule for his operations when necessary to remove a sewer line or structure from service. The schedule shall be coordinated with the ENGINEER and shall meet the restrictions and conditions specified in this section. The detailed plan shall describe the CONTRACTOR's method for preventing accidental discharges, the length of time required to complete said operation, the necessary plan and equipment which the CONTRACTOR shall provide in order to prevent accidental discharges.

The CONTRACTOR shall observe the following restrictions: Systems or individual equipment items shall be isolated, drained, decommissioned, de-energized, or depressurized in accordance with the detailed outage plan and schedule. The ENGINEER shall be notified in writing at least one week in advance of the planned operation.

- E. **Sewer Line Draining.** Sewers to be abandoned shall be flushed with two pipeline volumes of water and allowed to drain fully prior to abandoning.
- F. **Sewer Bypassing.** Sewer bypassing shall be accomplished by pumping or diverting the upstream flow around the CONTRACTOR's work or as directed by the ENGINEER. The CONTRACTOR shall provide temporary pumps, conduits, and other equipment to bypass the sewer flow.

CONTRACTOR shall furnish the necessary labor, equipment and material, and supervision to set up and operate the pumping and bypass system. Engines shall be equipped with mufflers and/or enclosed to keep the noise level within local ordinance requirements. Pumps and bypass lines shall be of adequate capacity and size to handle the flows.

Unless otherwise specified, the CONTRACTOR shall bypass flow around his work whenever the depth of flow, as measured at the inlet pipe to the upstream manhole adjacent to the CONTRACTOR's work, exceeds the crown elevation of the pipe; or whenever the CONTRACTOR's equipment operating in the sewer provides an obstruction that restricts flow and causes the depth of flow to exceed the crown elevation.

- G. **Standby Equipment.** The CONTRACTOR shall maintain on site sufficient equipment and materials to ensure continuous and successful operation of the bypass and dewatering systems. Standby pumps shall be fueled and operational at all times. The CONTRACTOR shall maintain on site a sufficient number of valves, tees, elbows, connections, tools, sewer plugs, piping and other parts or system hardware to ensure immediate repair or modification of any part of the system as necessary.

- H. Damages.** The CONTRACTOR shall repair without cost to the Utility any damage that may result from his negligence, inadequate or improper installation, maintenance, and operation of bypassing and draining equipment, including mechanical or electrical failures.
- 5. Flowable Backfill.** When indicated on the plans, trenches shall be backfilled to the elevations shown, with stabilized backfill meeting requirements of Item 401.
- 6. Cutting and Restoring Pavement.** Where sewers must be installed in streets or other paved areas, the work shall include saw cutting of the pavement and base to neat lines and prompt replacement of these materials after sewer excavation and backfill are completed. The replacement materials, as to type and thickness, shall be as shown on the plans. Any work done or damage to base and/or pavement outside the limits shown on the plans will not be measured for payment, but shall be restored at the CONTRACTOR's entire expense.
- 7. Measurement.**

- A. Sanitary Sewer Mains (PVC).** Longitudinal measurement of sanitary sewers will be made along the centerline of the sewer by the linear foot of the various sizes of sewers in place, in accordance with these specifications, complete and approved by the ENGINEER.

The lengths of sewer mains will be measured center of manholes where the installation involves connection of the sewer into a manhole at each end of the line being measured.

Where 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 center of the manhole on the work being measured.

- B. Sanitary Sewer Mains (DI).** Longitudinal measurement of sanitary sewers will be made along the centerline of the sewer by the linear foot of the various sizes of sewers in place, in accordance with these specifications, complete and approved by the ENGINEER.

The lengths of sewer mains will be measured center of manholes where the installation involves connection of the sewer into a manhole at each end of the line being measured.

Where 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 center of the manhole on the work being measured.

- C. Manholes.** All sanitary sewer manholes satisfactorily completed in accordance with the plans and specifications will be measured by each of the various manhole types based on a standard 6-foot depth.

Rings and Covers, stub-outs and drop connections, adjustment to temporary and finished grades, and temporary and permanent connections to existing and/or new pipes will not be measured for payment, but shall be considered subsidiary to the manhole unit.

- D. Manholes, EXTRA DEPTH.** This measurement shall be the distance from the top of the frame to the invert of the manhole less 6-feet.
- E. Sewer Service Re-Connections (Service Laterals).** Sewer Service Re-Connections (Service Laterals) will be measured by the linear foot of sewer service re-connections of a particular size installed and accepted.
- F. NEW Sewer Service (Service Laterals).** New Sewer Service (Service Laterals) will be measured by the linear foot of new sewer service connections of a particular size installed and accepted.
- G. Adjusting Manholes.** Existing manholes remaining in service and required to be adjusted to proposed grade will be measured by each manhole adjusted.
- H. Flowable Backfill.** This Item will be measured by cubic yard as shown under "Flowable Backfill," Item 401.
- I. Cutting and Restoring Pavement.** This will be measured by the square yard as shown under "Excavation and Backfill for Structures," Item 400.
- J. Remove Existing Manholes.** Existing manhole structures to be completely abandoned and removed as identified in the plans will be measured for each manhole removed.
- K. Abandon and Fill Existing Sanitary Sewer Pipe.** This Item will be measured by the linear foot of existing sanitary sewer main that is abandoned in place.

8. Payment.

- A. Sanitary Sewer Mains (PVC).** The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" herein will be made as follows. Sanitary Sewers will be paid for at the unit price bid per linear foot for "Sanitary Sewer Pipe (PVC)" of the type and size specified, complete in place.

Payment shall include all labor and materials for the pipe; potholing; excavation, including hand-digging, if needed, embedment and backfill; compaction and compaction testing for utilities, all fittings; removal and disposal of existing manholes, except where indicated as being covered under a specific bid item; pipe connections to existing manholes; relocation or replacement of existing water and sewer lines required for placement of new sewer line; pipe concrete caps; plugs (temporary and/or permanent); testing; dewatering of groundwater, if needed; bypassing and any work related to the bypass including traffic control related to bypasses; removal and replacement of storm drains; removal and replacement of drainage structures; placing and joining of pipes and fittings; traffic control required for sewer work outside Project limits; coordination with utility companies, EPWU, and ENGINEER; locating and protecting of existing utilities; and for all other items of material, labor, equipment, tools and incidentals necessary to complete the work in accordance with the plans and specifications.

- B. Sanitary Sewer Mains (DI).** The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" herein will be made as follows.

Sanitary Sewers will be paid for at the unit price bid per linear foot for "Sanitary Sewer Pipe (DI)" of the size specified, complete in place. Payment shall include all labor and materials for the pipe; potholing; excavation, including hand-digging, if needed, embedment and backfill; compaction and compaction testing for utilities, all fittings; removal and disposal of existing manholes, except where indicated as being covered under a specific bid item; pipe connections to existing manholes; relocation or replacement of existing water and sewer lines required for placement of new sewer line; pipe concrete caps; plugs (temporary and/or permanent); testing; dewatering of groundwater, if needed; bypassing and any work related to the bypass including traffic control related to bypasses; removal and replacement of storm drains; removal and replacement of drainage structures; placing and joining of pipes and fittings; traffic control required for sewer work outside Project limits; coordination with utility companies, EPWU, and ENGINEER; locating and protecting of existing utilities; and for all other items of material, labor, equipment, tools and incidentals necessary to complete the work in accordance with the plans and specifications.

- C. Manholes.** The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" herein will be made as follows. Payment for all sanitary sewer manholes, including all material, labor, gaskets, rings, covers, concrete collars, pipe penetrations, drop connections, grout, groundwater dewatering, testing, concrete, excavation and backfill, grouting of inverts, coating interior and exterior where required, adjustment of new manhole to both temporary and finished grades, and all other incidentals necessary to comply with the specifications and the details indicated on the drawings, measured as provided above, shall be made at the unit price bid for each "Sanitary Sewer Manhole 6-foot depth" of the size and type specified or indicated on the drawings.
- D. Manholes, EXTRA DEPTH.** Work under this item includes furnishing all labor, new materials and equipment and performing all operations necessary to construct the depth of sanitary sewer manhole in excess of 6-feet; including but not limited to providing an external protective bituminous coating, such as coal-tar epoxy.
- E. Sewer Service Re-Connections (Service Laterals).** The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" herein will be made as follows. Payment for service laterals shall include all labor and materials for the pipe; excavation and backfill; fittings; cutting; bypassing; coordination; testing; and plugging/capping of abandoned utilities; draining of lines; vertical and horizontal adjustments; connections to existing sewers; and all other incidentals necessary to comply with the specifications or the details indicated on the drawings measured as provided above, will be made at the unit price bid for each "Sewer Service Re-Connection" of the particular size installed.
- F. NEW Sewer Service (Service Laterals).** The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" herein will be made as follows. Payment for service laterals shall include all labor and materials for the pipe; excavation and backfill; fittings; cutting; bypassing; coordination; testing; and plugging/capping of abandoned utilities; draining of lines; vertical and horizontal adjustments; connections to existing sewers; and all other incidentals necessary to comply with the specifications or the details indicated on the

drawings measured as provided above, will be made at the unit price bid for each "New Sewer Service Lateral" of the particular size installed.

- G. Adjusting Manholes.** The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" herein will be made as follows. Manholes adjusted, will be paid for the at the unit price bid for each "Adjusting Manhole". This payment will be for all labor, materials, plugs (temporary and permanent), excavation and backfill, cement stabilized backfill, groundwater dewatering, removal, disposal of materials, and all other incidentals necessary to comply with the specifications and the details indicated on the drawings.
- H. Flowable Backfill.** Measured as provided under "Measurement" and will be paid for at the unit bid price for "Flowable Backfill," Item 401.
- I. Cutting and Restoring Pavement.** Measured as provided under "Measurement" and will be paid for at the unit bid price for "Excavation and Backfill for Structures," Item 400.
- J. Remove Existing Manholes.** The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" herein will be made as follows. Manholes removed, will be paid for the at the unit price bid for each "Remove Existing Manhole". This payment will be for all labor, materials, plugs (temporary and permanent), excavation and backfill, cement stabilized backfill, groundwater dewatering, removal, disposal of materials, and all other incidentals necessary to comply with the specifications and the details indicated on the drawings
- K. Abandon and Fill Existing Sanitary Sewer Pipe.** The work performed and the materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Abandon and Fill Existing Sanitary Sewer Pipe" of the size specified. This price shall be full compensation for furnishing all required materials, labor, and equipment, including but not limited to the following items: coordination, traffic control, potholing, excavation, complete flushing and draining (dewatering) of pipe, flowable backfill, cutting, capping/plugging, complete filling with approved flowable backfill of sanitary sewer mains to be abandoned, proper abandonment of all manhole structures with flowable backfill as indicated on the plans, and all other items for the project not indicated as being covered under the other specific bid items shown on the proposal.

X. CASINGS

1. **Description.** This Item shall govern for the construction of steel casing and installation of approved carrier pipes within the casing. The CONTRACTOR shall install casings at the locations and to the lines and grades indicated on the drawings, of the sizes indicated, using either jacking, boring, tunneling, or approved open-cut methods. The CONTRACTOR shall install carrier pipes of the sizes indicated on the drawings within the casings, and he shall install the required vent piping, casing insulators (casing insulated spacers), end seals, pipe supports and skids, and other incidental features required to complete work described in this section and as shown on the drawings.
2. **Materials.** The CONTRACTOR shall furnish all materials, equipment, tools, labor, superintendence, and incidentals, including all necessary field welding, to install casings, carrier pipes and accessories as indicated on the drawings and as specified herein. The CONTRACTOR shall provide adequate lights, ventilation, signal systems, fire extinguisher, safety equipment, and other equipment required and maintain such equipment in good repair.

The CONTRACTOR shall be solely responsible for determining soil conditions at the various locations where casings are to be installed, and he shall make such other investigations to obtain that information as he may deem necessary. The costs of such investigations shall be included in the CONTRACTOR's cost for performing the work.

Methods of construction, whether by tunnel boring machine or by hand digging, shall be at the CONTRACTOR's option subject to the approval of the governing agencies and approval of the ENGINEER.

The work of excavating, lining, grouting and construction of the casing or tunnel shall be so executed that ground settlement is minimized.

Where casings are installed by open-cut method, all requirements for trenching and backfilling as described in these specifications shall apply, except as otherwise required by the plans or supplemental specifications.

Access shafts or pits shall be located at the beginning and end of each casing or tunnel segment to be constructed.

Unless superseded by the requirements of other governing authorities under whose facilities or right-of-way the casing is to be installed, the face of any shaft shall be at least 20-feet from existing adjacent roadways or structures. Sizing of shafts or pits shall provide adequate room to meet the CONTRACTOR's operational requirements for tunnel construction.

- A. **Submittals:** CONTRACTOR shall submit for review complete working drawings which show details of the proposed method of construction and the sequence of operations to be performed during construction. The plan shall show the method of jacking, boring, or tunneling, muck removal and disposal, type and method of installation of the primary casing or tunnel liner, access pit size and construction shoring and bracing, and dewatering methods proposed.

Drawings shall be sufficiently detailed to allow the ENGINEER to judge whether or not proposed materials and procedures will meet the contract requirements.

The CONTRACTOR's submittal shall include the design criteria used and a certification that the structural design of the casing or tunnel liner meets these design criteria and that the material meets the required ASTM Standards. The tunnel liner shall be capable of carrying H-20 vehicle load distributions in accordance with AASHTO as well as the anticipated dead loads and include an appropriate design factor of safety.

The submittal shall also include the layout and design of the access shafts. A certification shall be submitted that the structural design of the shoring and bracing meets the design criteria as submitted by the CONTRACTOR.

All structural designs shall be sealed by a Professional Engineer licensed in the State of Texas and qualified to perform such work.

- B. Standards:** All OSHA regulations and all requirements of the specific private and governmental agencies under whose facilities the casings and pipe area to be installed shall apply to these operations.

The CONTRACTOR shall be responsible for protecting the facilities under which the casings and pipe are installed, for providing protection at the excavations, and for carrying out the trench safety procedures per all OSHA regulations that may be required because of these operations.

Referenced within this section is the "Standard Specification for Construction of Highways, Streets and Bridges," most current Edition of the Texas State Department of Highways and Public Transportation (now called the Texas Department of Transportation), and hence referred to herein as TxDOT-Specification.

- C. Materials:** Steel Casing Pipe shall be new, unused, and suitable for the purpose intended and shall have a minimum yield strength of 35,000 psi. Casing shall meet ASTM A-53 or approved equal. Pipe shall be coated and lined with coal tar epoxy (15 mils min.) in accordance with AWWA C-210. Pipe joints shall be welded in accordance with AWWA C-206. After pipe is welded, coating and lining shall be repaired. Unless specified otherwise, the minimum wall thickness of steel casing pipe shall be 0.3125 (5/16) inches.

Tunnel Liner shall be constructed of cold-formed steel plates of the sizes, thickness, and dimensions required, as indicated on the drawings, and as manufactured by Commercial Shearing, Contech, or equal.

Reinforced Concrete Pipe for casing where specified or shown shall be straight-wall RCP pipe casing conforming to ASTM C-76 Class IV of the size and length specified.

Grout Holes shall be welded half-coupling. Tapped holes shall be provided with a pipe plug screwed in place.

Bolts and Nuts with liner plates shall be not less than 1/2 inch diameter and conform to ASTM A-307 Grade A.

3. Execution.

- A. Installation of Casings:** Casings shall be installed using either jacking, boring, or tunneling methods. Equipment used in this work shall be of such size and capacity as to allow the placement of the casings to proceed in a safe and expeditious manner.

Casing pipe shall be installed from the end which will create a minimum of access and utility relocation problems. Prior to casing installation, CONTRACTOR shall pothole utilities and all other permanent structures within the project area in order to identify potential conflicts. In the event a conflict exists, CONTRACTOR shall notify ENGINEER before proceeding with casing installation so a solution can be formulated.

Lateral or vertical variation in the final position of the pipe casing from the line and grade established by the ENGINEER shall be permitted only to the extent of 1-inch in 10-feet, provided that such variation shall be regular and only in the direction that will not detrimentally affect the function of the carrier pipe. Casing pipe found to be considerably off-grade or alignment shall be removed and re-installed, or abandoned and another casing placed as required at no additional cost to the Utility.

Any detectable settlement of the roadway overlying the casing or tunnel shall be immediately repaired at the CONTRACTOR's expense. Slight settlement of the roadway, should it occur, shall result in cessation of casing/tunneling operations, posting of appropriate highway safety signs, and placement of an asphaltic hot-mix overlay to return the roadway to original grade. Over-cutting in excess of 1-inch shall be pressure grouted the entire length of the bore with 7-sack cement per cubic yard of soil mixture, at the Contractor's expense. Where applicable, hot-mix shall meet the requirements of TxDOT-Specifications. The surface to receive hot-mix shall be primed as directed by the ENGINEER. The CONTRACTOR shall submit an emergency road repair procedure plan to the Texas Department of Transportation or applicable governing agency, prior to beginning any casing/tunneling operations.

When installing casing by boring, installation of the casing and the excavation and removal of the material within the casing shall proceed simultaneously. The completed casing shall be free of dents, bends, weld protrusions, or other obstructions to allow the smooth sliding of the carrier pipe through the casing.

- B. Installing Casing By Tunneling:** The tunnel shall be of sufficient size to permit efficient excavation operations, to provide sufficient working space for placing the tunnel lining, and to allow for construction of the carrier pipe as shown on the drawings or indicated on the specifications. Determination of an adequate tunnel size and section to meet these requirements shall be the sole responsibility of the CONTRACTOR. It shall be understood and agreed that the dimensions shown on the drawings represent the approximate dimensions acceptable to the ENGINEER and do not necessarily represent the size and/or section suitable for the construction methods or operational procedures as may be proposed and/or conducted by the CONTRACTOR.

Casing pipe to be installed by tunneling methods shall use structural steel plates assembled from the inside of the tunnel and field bolted to provide a full round casing pipe. Excavation for tunnel shall be held to the minimum possible diameter required for installation of liner plate.

The limits of excavation shall be as required to prevent caving. The annular space between the tunnel liner and the tunnel bank shall be pressure grouted. Grouting shall be accomplished through 2-inch diameter plugs provided in the liner plates at spacing of 5'-0" or as specified by the ENGINEER. Any excess groundwater encountered shall be removed by the CONTRACTOR in a manner to allow the tunneling operation to proceed according to schedule.

- C. Installation of Carrier Pipe In Casing Pipe Or Tunnel Liner:** After the casing or tunnel liner has been installed and approved by the ENGINEER, the carrier pipe shall be pushed or pulled through the casing by exerting pressure on the barrel of the pipe in such a manner that the pipe joints are always in compression.

Insulated spacers shall be used when specified for providing cathodic protection. Pipeline spacers shall consist of pre-manufactured steel bands with plastic lining and plastic runners. Casing spacers shall fit snug over the carrier pipe and position the carrier pipe approximately in the center of the casing pipe, to provide adequate clearance between the carrier pipe bell and the casing pipe. Casing spacers shall be Model C12G-2, coated for the ultimate in strength, toughness and corrosion resistance, or Model A12G-2, painted for unusually heavy pipe, for long casings or whenever maximum strength and toughness are required, as directed by the ENGINEER, for carrier pipes 4" - 56" in diameter. Casing spacers shall be as manufactured by Pipeline Seal and Insulator, Inc. (PSI) or approved equal.

The carrier pipe shall be installed in the casing in accordance with the recommendations of the pipe manufacturer.

If tunnel liner is used, the bottom 120 degrees of the liner shall be grouted to the top of the tunnel liner ribs to aid in the installation of the carrier pipe.

After installation of the carrier pipe inside the casing pipe or tunnel liner, the ends shall be sealed to prevent water or other material from entering the casing or liner and causing corrosion. Method of sealing the ends shall be one of the following methods as directed or specified:

1. End shall be sealed by method of Brick and Mortar.
2. End shall be sealed with Bulkhead and Grout.
3. End shall be sealed with a synthetic rubber end seal. End Seals shall be PSI, Inc. Standard Pull-On (Model C), or approved equal. The end seals shall be appropriate for the size and type of carrier pipe and casing.

Steel casings shall include a precautionary outlet and bonnet box at each end of the casing, as shown on the drawings.

- D. Grouting:** Unless otherwise specified or directed by the ENGINEER, grout material shall be ordinary cement-sand grout as described in Article III of these Specifications.

Fill all excavation outside the casing or tunnel liner with pressure-applied grout or other approved fill unless otherwise directed by the ENGINEER.

Use care in grouting operations to prevent damage to adjacent utilities or other properties. Pressure used in grouting shall not be great enough to distort or imperil any portion of the work.

All voids outside the limits of the casing or tunnel excavation created by caving or collapse of earth cover over the excavation, or by other cause shall also be completely filled with grout. All grouting to eliminate voids outside the casing or tunnel limits shall be at the CONTRACTOR's expense.

When hand-tunneling methods are used, place grout behind the tunnel liner at the end of each day or at every 10 feet of tunnel installed, whichever spacing is acceptable to the ENGINEER.

The annular space between the casing and carrier pipe shall be treated by one of the following methods as directed or specified. Where applicable, the annular space shall be filled according to the regulations specified by the governing agency for the area where the casing is to be installed.

1. Annular space shall be left open for cathodically protected systems where both casing and carrier pipes are metallic material.
2. Annular space shall be filled with pneumatically placed sand. This shall be the standard method for pipes in all installations other than groundwater.
3. Annular space shall be filled with grout. Pressure used to grout shall be such that the carrier pipe is not damaged or distorted. Submit method for approval prior to starting work. This method is mandatory for installations in groundwater, optional on all other dry installations.

4. Measurement.

A. This Item will be measured in place by the foot of Casing installed.

B. Casing for temporary water and/or sanitary sewer by-pass lines will not be measured for payment and shall be considered incidental to the various pay items.

- 5. Payment.** The work performed and the materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Casing" of the type, size and installation method specified. This price shall be full compensation for coordination; excavation; disposal of excess material; grouting; backfilling; compaction; compaction testing for utilities; furnishing and installing the approved carrier pipe, precautionary outlet with bonnet box, and accessories as per specifications and standard details by means of open cut (where indicated), and bore and jacking methods (where indicated), welding, furnishing and installing steel casing insulators, and all appurtenances described herein to include, but not limited to the following items: locating, protecting, supporting, relocating if required, and repairing damage to any utilities or structures encountered in the process of the work, dewatering and disposal for water where required, paving cut, removal and repair as needed, traffic control plan, excavation for bore pits, and all other items of the project not indicated as being covered under the other

specific bid items shown on the Proposal. Such payment shall be complete compensation for the complete performance of the work in accordance with the drawings and the provisions of these specifications. Traffic control, backfill, and pavement repair where needed shall be in accordance to the governing agency (City of El Paso for City Streets and TxDOT for State right-of-way).

**SPECIAL PROVISION
TO
SPECIAL SPECIFICATION
5878--002
WATER AND SANITARY SEWER SYSTEMS**

For this project, Special Specification Item 5878, "WATER AND SANITARY SEWER SYSTEMS," is amended with respect to the clauses cited below, and no other clauses or requirements of this Item are waived or changed.

Subsection IV.3.D4. Compaction and Testing Final Backfill is voided and replaced by the following:

For all backfill in the areas not in existing or proposed paved streets, obtain density of not less than 90% ASTM D-1557 from top of pipe bedding to ground surface.

Subsection IX.3.B.9. Installation. The fifth paragraph is voided and replaced by the following:

Externally coat all manholes in groundwater with a bituminous coating such as Coal Tar Epoxy. Interior coating is required on all manholes and shall be an epoxy resin-type material such as Plascite 7122 or approved equal.

Subsection IX.7.C. Manholes. The second paragraph is voided and replaced by the following:

Rings and covers, stub-outs and drop connections, ventilation, exterior and interior coatings, adjustment to temporary and finished grades, and temporary and permanent connections to existing and or new pipes will not be measured for payment, but shall be considered subsidiary to the manhole unit.

Subsection IX.8.A. Sanitary Sewer Mains (PVC) is 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 at the unit price bid per linear foot for "Sanitary Sewer Pipe (PVC)" of the type and size specified, complete in place.

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid at the unit price bid per linear foot for "Sanitary Sewer Pipe (PVC)" of the type and size specified, complete in place. Payment shall include all pipe materials and labor; potholing; excavation by hand or machine; embedment and backfill; compaction and compaction testing for utilities; fittings; removal and disposal of existing manholes, unless covered under a specific bid item; pipe connections to existing manholes; relocation or replacement of existing water and sewer lines required for

placement of new sewer line; pipe concrete caps; concrete encasement; plugs (temporary or permanent); testing; dewatering of groundwater, if needed; bypass and any work related to the bypass including traffic control related to bypass; removal and replacement of storm drains; removal and replacement of drainage structures; placing and joining of pipes and fittings; traffic control required for sewer work outside project limits; coordination with utility companies, EPWU , and Engineer; locating and protecting of existing utilities; and for all other items of material, labor, equipment, tools, and incidentals necessary to complete the work in accordance with the plans and specifications.

Subsection IX.8.C. Manholes is 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 made for all sanitary sewer manholes, including all materials, labor, gaskets, rings, covers, concrete collars, pipe penetrations, drop connections, ventilation, grout, groundwater dewatering, testing, concrete, excavation and backfill, grouting of inverts, coating interior and exterior where required, adjustment of new manhole to both temporary and finished grades, and all other incidentals necessary to comply with the specifications and details indicated on the drawings, measured as provided above, shall be made at the unit price bid for each “Sanitary Sewer Manhole 6-foot depth” of the size and type specified or indicated on the drawings.

Subsection IX.8.D. Manholes, EXTRA DEPTH is voided and replaced by the following:

Work under this Item includes furnishing all labor, new materials and equipment, and performing all operations necessary to construct the depth of sanitary sewer manhole in excess of 6 feet; including but not limited to providing an interior and exterior coating where required.

Subsection X.2.C. Materials. The first paragraph is voided and replaced by the following:

Steel Casing Pipe shall be new, unused and suitable for the purpose intended, and have a minimum yield strength of 35,000 psi. Casing shall meet ASTM A-53 or approved equal. Coat and line pipe with coal tar epoxy (15 mils min.) in accordance with ASTM C-210. Weld pipe joints in accordance with AWWA C-206. After pipe is welded, repair coating. Unless specified otherwise, the minimum wall thickness of steel casing pipe shall be 0.5000 (1/2) inches.

Subsection X.3.C. Installation of Carrier Pipe in Casing Pipe or Tunnel Liner. The fifth paragraph is voided and replaced by the following:

After installation of the carrier pipe inside the casing pipe or tunnel liner, the ends shall be sealed to prevent water or other material from entering the casing or liner and causing corrosion. End shall be sealed with a synthetic runner end seal. End seals shall be PSI, Inc. Standard Pull-On (Model C), or approved equal. The end seals shall be appropriate for the size and type of carrier pipe and casing.