REQUEST FOR PROPOSAL MID IFB 2017-12
CONTRACTOR SERVICES
PIONEER SUBSTATION MODIFICATION

Attachment MID Pioneer Substation, 115-12.47 kV Substation, Construction Specification, Spec. No. 82301-16

MID PIONEER SUBSTATION
115-12.47 kV SUBSTATION
CONSTRUCTION SPECIFICATION
SPEC. NO. 823-16

Prepared for:

Merced Irrigation District

MERCED IRRIGATION DISTRICT
WATER & POWER

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RELEASED FOR BID

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Revision Chart

Rev	Reason for Change	Author	Reviewer	Approved by	Issue Date
0	Released for Bid	KJL	OH	NF	11/03/17
1	Released for Bid (general changes)	KJL	NF	NF	11/17/17
2	Released for Bid (chgs. From client)	KJL	NF	NF	11/20/17

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1.0 General

1.1 PROJECT SCOPE AND GENERAL OVERVIEW

Merced Irrigation District (Owner), a public utility, plans to contract minor material procurement, and construction responsibilities to a Construction Contractor (Contractor). MID has contracted preparation of the detailed design package and major material specifications to a consulting services provider, referred to as the "Engineer". The Owner, Contractor, and Engineer are identified along with their key personnel in Appendix B of this specification.

The Owner will provide procurement services, unless specifically included in the Contractor's scope, for longer lead time material items, including solicitation of proposals, evaluation, and issuance of the purchase order. Either the Owner or the Contractor, whichever is issuing the purchase order, may be referred to herein as the "Purchasing Authority".

Reference to the Supplier within this specification is intended to mean the equipment manufacturers, their authorized sales representatives, their authorized distributor, and/or their subcontractor.

This Construction Specification is intended to provide for the complete construction, installation, testing and commissioning, of the MPT 3 addition to the existing 115/12.47 kV Pioneer Distribution Substation. Pioneer Substation and particularly the addition of MPT 3, referred to as Phase 3, may also be referred to hereafter simply as the Project.

The design document package which accompanies a "Released for Construction" specification is intended to be complete and should be considered a 100% complete package. However, this specification and the accompanying design document package may be released at some percentage of completion prior to being released for construction so that the Owner may select a Contractor and start the permitting process.

The Project is to be built under a procure/construct contract (PC) issued by the Owner. The Owner will provide a detailed design document package prepared by their contracted Engineer. Upon completion of the project, the Contractor will turn over to the Owner, a fully commissioned and fully functional 115/12.47 kV Substation (Substation), ready for energization and being placed into service. The Contractor shall provide directly, or otherwise subcontract for, all materials, equipment, with the exception of those items identified herein as being Owner Furnished, personnel, expertise, necessary to provide the Owner with a fully functional Substation.

1.2 LOCATION OF WORK

The work as described shall take place at the Pioneer Substation site located in Merced County, California north of the City of Livingston, California (see Appendix B for further information). The Project shall be constructed within the fenced area of the existing substation, just north of Olive Avenue, and the Foster Farms processing facility The substation is currently fed from four (4) incoming 115 kV transmission lines approaching the station from the north. 12.47 kV underground distribution facilities leave the station from the south. Overhead distribution facilities fed by risers are the south and east sides outside of the fenced station area. The substation property is bounded on the west side by an irrigation canal.

2.0 Work Description-General

The Substation provides a transmission interconnection to four (4) 115 kV transmission lines served by a breaker-and-a-half bus arrangement, which is currently configured as a 6-segment ring bus.

Incoming power is delivered by two (2) lines connected to TID's transmission system. Outgoing power serves the MID Castle and Cooper Substations.

Two (2) of the existing ring bus nodes serve distribution load through an existing Main Power Transformers (MPT) 1 and 2. The Project will bifurcate the existing bus node serving MPT 2, between 115 kV circuit breaker Device #1810 and #1820.

In order to improve reliability, a separate high-side circuit breaker will be installed for both the existing MPT 2 and the new MPT 3 (Device #718 and #728 respectively), add an isolating disconnect switch between each high-side circuit breaker and the bifurcated bus node (Device #1828 and #1928 respectively).

In an effort to maintain an access road between the transformers and 115 kV Main Bus 2, the high-side disconnecting switches will be located on an H-frame deadend structure lower crossbeam. Since the existing deadend structures cannot be modified to add a lower crossbeam, two (2) new H-Frame deadend structures will be added.

A "jack" bus will be constructed to connect the bifurcated node on the 115 kV ring bus to the adjacent future breaker-and-a-half bay. The existing suspension bus in the third breaker-and-a-half bay will be adapted to feed MPT 3 high-side breaker.

A new 12.47 kV Main/Transfer Bus Section 3 will be added to the low-side of the new MPT 3. The 12.47 kV switch and bus will consist of six (6) breaker bays:

- One (1) bay configured as the Main Breaker (Device #13) bay;
- Three (3) bays configured as underground distribution circuit breaker bays, with one of the three designated as a future feeder (circuit breaker Device #9).

The two (2) underground distribution circuit breaker bays will contain circuit breaker Device #1 and #2.

A fifth breaker bay is designated as a reactive power support breaker bay, which will connect a 2-step capacitor bank to Bus Section 3. The circuit breaker (Device # 8) will be installed under the Project's initial construction phase.

The sixth breaker bay is designated as the substitute breaker bay. It will be fitted with a circuit breaker (Device #20) that can be fed from either the main bus in Section 3 or the future bus in Section 4, and feed the transfer bus in either Section 3 or the future transfer bus in Section 4.

A series of bus sectionalizing switches will be added to both the 12.47 kV main and transfer buses in Bus Section 3. Initial construction will include a bus sectionalizing switch (Device #S23) to segregate the main bus between the existing Bus Section 2 and the new Bus Section 3.

Initial construction will also include a bus sectionalizing switch (Device #S11) to segregate the transfer bus between the existing Bus Section 2 and the new Bus Section 3. Bus Sectionalizing Switch Device #S24 will also be installed on the main bus with Bus Section 3, providing an isolation point for the future addition of Bus Section 4. Bus sectionalizing switch Device #S25 is identified on the Operation Single Line Diagram (Drawing #PI509), however, it and the two sectionalizing switches on the transfer bus associated with the Substitute Breaker Device #20 will not be installed under the Project's scope.

Each of the six (6) 12.47 kV breaker bays will be fitted with manually-operated hookstick style breaker disconnect switches, designated with an "A" or a "B", regardless of whether the circuit breaker is being installed under the Project's current scope. Additionally, each of the breaker bays will be fitted with circuit breaker foundations, below-grade conduits, ground pigtails, and the full complement of support structure members, regardless of whether the circuit breaker is being installed under the Project's current scope.

A seventh partial 12.47 kV switch and bus bay will be installed between the Bus Section 3 main breaker bay and the existing Bus Section 2 switch and bus. This seventh bay will accommodate the Bus Section 3 station service transformer, with its primary fused disconnect switch served by a single-phase (C-Phase) of the Bus Section 3 Main Bus. To match existing station service transformer primary connections, the new station service transformer will be connected phase-to-ground rather than the preferred phase-to-phase connection. Structural provisions will be made to accommodate phase-to-phase connection in the future.

12.47 kV Bus Section 3 will be fitted with a 3-phase set of single-phase voltage transformers, with the primary protected by a fused disconnect switch. Each VT will have their primary connected phase-to-ground. Bus VT's are to be connected to the main bus, such that removing the bus section's associated power transformer from service does not result in a loss of potential.

12.47 kV reactive power support Shunt Capacitor Bank #3 will be installed as part of this project. Initial construction will include the conduit, risers, 12.47 kV underground cable, and cable terminations to a common bus feeding each of the shunt capacitor bank steps. Install the foundations reactive switching devices (Southern States Model 38M CapSwitchers), and the capacitor block rack and support structure, neutral VT's, and 4-pole grounding switch associated with each of the two (2) steps. Shunt capacitor bank steps are planned for six (6) 200 kVAr capacitor units per phase per step, with provisions for a full complement of twelve (12) 200 kVAr capacitor units per phase per step.

Control and protection equipment associated with the MPT 3 addition, as well as the #2 high-side circuit breaker and disconnect switch, will be located on relay panels located within the existing control enclosure. Four (4) new rack/panels will be added to accommodate the MPT 3 protection package, as well as initial construction related to the 12.47 kV Bus Section 3 circuit breakers and future shunt capacitor bank.

The Owner has determined that if and when a fourth MPT and 12.47 kV Bus Section 4 is to be added, that at that time a new control enclosure will be installed which would ultimately house all of the control and protection elements for new and existing equipment within the substation.

The existing conduit system has a bottleneck between Pull Box #1 and the cable trench within the existing control enclosure. The Owner has chosen to install a new conduit duct bank running from the control enclosure (new Pull Box #5) and new Pull Box #10. Pull Box #5 will connect to control and relay panels within the existing control enclosure via a vertical cable tray on the enclosures exterior to a horizontal cable tray system located above the new control and relay panels. A short 20-foot section of pedestrian rated surface trench will be installed between Pull Box #7 and #8, to facilitate crossing over the existing duct bank servicing MPT 1 and 2.

The medium-voltage portion of the Substation (energized at 12.47 kV) is specifically comprised of modular 9-foot open-air switch and bus bays, with a main bay (Structure #S27), and Extension bays (Structure #S28 and #S29) extending from the main bay in either direction.

Each bay is designed with symmetrical multi-purpose crossbeam attachments, which allow the main bus to be tapped in either direction. The top crossbeams are designed to support both a main and transfer buses, however, the Owner has elected to have phase-to-phase bus separation which is less than APLEC compliant phase spacing.

Bays serving either a distribution circuit or reactive power support position are not capable of being bifurcated at the switch and bus structure using isolating disconnect switches. A 3-phase set of single-pole tandem hookstick style switches will allow either a distribution circuit or reactive power support position to be connected to its associated circuit breaker or to the transfer bus.

The medium-voltage circuit breaker within each bay will be isolated from the main bus and outgoing distribution/reactive power support circuit by two (2) 3-phase sets of single-pole hookstick style switches. The Owner has elected to orient the main and transfer buses in the same manner as the existing bus section, specifically with the main bus located towards the outgoing distribution facilities, and the transfer bus closest to the MPT.

12.47 kV Bus Section #2 bus potential devices will be deleted from their existing locations. Install new bus potential devices on the new Bus Section #3 steel structures connected to the Bus Section #2 side of the main bus sectionalizing switches, (Device #S 21). Relocate the underground connection between Bus Section #2 and the existing Shunt Capacitor Bank #2. Replace the fused disconnects and locate them on the Bus Section #3 steel structure.

The station service transformer located within 12.47 kV Bus Section #1 is to be replaced with a new pole-mounted type 75 kVA station service transformer. The Contractor will install the Owner Furnished transformers. The Contractor will furnish and install new primary fusing, secondary conductor to the control enclosure, fused safety disconnects for both sources, and a manual transfer switch.

3.0 Publications, Certifications and Practices

3.1 PUBLICATIONS

The following publications shall be used in conjunction with this material specification, and form a part of this specification to the extent specified herein. When a referenced publication is superseded by an approved revision, the revision shall apply. Referenced industry publications are listed below.

Applicable industry documents may include, but shall not necessarily be limited to, those listed below. See Project Information appendix for local jurisdiction requirements.

All Contractor supplied equipment, construction methods, techniques and practices, shall be in accordance with the latest applicable ANSI, IEEE, NEMA, ASTM, and NFPA standards, and the latest applicable codes, unless otherwise specifically exempted by this specification or the Authority Having Jurisdiction (AHJ).

American Concrete Institute (ACI)	
ACI-301	Specifications for Structural Concrete for Buildings
ACI-318	Building Code Requirements for Structural Concrete
American Association of State Highway and Transportation Officials (AASHTO)	
American Society of Mechanical Engineers (ASME)	
ASA B27.1	Lock Washers
American National Standards Institute (ANSI)	
American Society for Testing and Materials (ASTM)	
	ASTM Specifications identified herein
A-6	Standard Specification for General Requirements for Rolled Steel Plates, Shapes, Steel Piping, and Bars for Structural Use
A-36	Standard Specification for Structural Steel
A-53	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless (Grade B Type E or S only)
A-123	Standard Specification for Zinc (Hot-Dipped Galvanized) Coatings on Iron and Steel Products
A-143	Standard Practice for Safeguarding Against Embrittlement of Hot-Dipped Galvanized Structural Steel Products and Procedure for Detecting Embrittlement
A-153	Standard Specification for Zinc Coating (Hot-Dipped) on Iron and Steel Hardware
A-307	Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength
A-325	Standard Specification for Structural Bolts, Steel, Heat Treated, 125/205 ksi Minimum Tensile Strength
A-384	Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dipped Galvanizing of Steel Assemblies
A-385	Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dipped)

A-500	Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
A-563	Standard Specification for Carbon and Alloy Steel Nuts
A-780	Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dipped Galvanized Coatings
Concrete Reinforcing Steel Institute (CRSI)	
	Manual of Standard Practice
Institute of Electrical and Electronics Engineers	
IEEE 80	Guide for Safety in Substation Grounding
ANSI/IEEE 400	IEEE Guide for Field Testing of Laminated Dielectric, Shielded Power Cable Systems Rated 5 kV and above with High Direct Current Voltage
ANSI/IEEE 48	Draft Standard for Test Procedures and Requirements for Alternating Current Cable Terminations Used on Shielded Cables having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV (Revision of IEEE 48-1996)
Insulated Cable Engineers Association (ICEA)	
International Electrical Testing Association (NETA) – Certifications	
National Electrical Manufacturers Association (NEMA)	
National Fire Protection Association	
NFPA 70	National Electric Code
NESC	National Electrical Safety Code
American Welding Society	
AWS-D1.1/D1.1M	Structure Welding Code – Steel
American Institute of Steel Construction (AISC)	
	Steel Construction Manual
	AISC Seismic Design Manual

3.2 CERTIFICATIONS

Materials and equipment shall be suitable for the use intended and labeled and/or listed or certified as acceptable to the approving authority and/or agency having jurisdiction.

3.3 PRACTICES

It is the Supplier's responsibility to be knowledgeable and employ designs and practices that incorporate the latest revisions of these standards where and when applicable.

4.0 General Technical Specifications

4.1 PERIOD OF PERFORMANCE

Work shall commence upon either receipt of executed contract or as per instructions by Owner. All work shall proceed in accordance with the approved Project Schedule.

The station Contractor shall have all work completed and the Substation ready for energizing per the schedule outlined in the Owner's Request for Proposal, and as amended per the construction contract, limited notice to proceed, notice to proceed, work order, or change order. All construction, testing and commissioning that can be done without MPT 3 installed and operational shall be completed prior to the date of initial energization. All other commissioning shall be completed per the schedule outlined in the Owner's Request for Proposal, and as amended by contract. The Contractor shall coordinate construction, testing, and commissioning activities within the Substation with the Owner. In some cases, reference to "Others" is only intended to identify activities not necessarily defined as "Substation", or "Substation Only".

4.2 CONSTRUCTION SCHEDULE

Contractor shall submit upon contract award and prior to the start of work, a detailed bar chart type "Project Schedule" for this work. This document upon acceptance by Owner shall become the "Project Schedule".

Contractor agrees to provide management, administration, and control of its own work or the work of its subcontractors of any tier, that may be required to assure completion of the work in accordance with the milestone dates of the Project Schedule.

Contractor shall perform and complete each segment of the work in accordance with the approved Project Schedule, unless otherwise accepted, in writing, by Owner.

5.0 Major Equipment and Materials

5.1 OWNER PROVIDED SERVICES

Owner shall provide onsite job construction inspection personnel to monitor quality of workmanship and materials, and schedule adherence by Contractor.

Owner shall provide technical assistance where necessary, and coordination between Contractor, Engineers and Vendors.

The Owner shall contract and supervise work to be performed by others as described in this specification. Specifically, the following tasks shall be performed by Others:

1. The MPT will be set on the Contractor supplied foundations and dressed-out by the Owner. The Owner will be responsible for the field commissioning of the transformer, particularly those tasks which are performed prior to initial energization. However, the Contractor is responsible for anchoring each transformer base to the foundation embedment's, grounding connections to the tank ground pads, and grounding connections between the tank ground pads and the neutral and surge arrester ground bus bars. The Contractor is also responsible for high and medium-voltage bus connections to the HV (H1, H2, and H3) and LV (X1, X2, and X3) phase bushing spade terminals. Conduit/wireway/trench, low-voltage control, protection, and station service wiring between the transformer control compartment and the control enclosure relay/control panels are also the responsibility of the Contractor.

2. The Contractor shall coordinate work efforts with the Supplier(s) to enable the Owner, Suppliers, and/or their subcontractors to utilize the Contractor's support personnel effectively. The Contractor shall provide to the equipment Supplier, ease of site access, foundation, including attachment of equipment to the foundations, and properly maintained workspace. Contractor shall be available to provide other 'on site' assistance as may be necessary to support construction activities being performed by the Owner and/or Suppliers of equipment purchased by the Owner.

5.2 CONTRACTOR RESPONSIBILITIES - GENERAL

Contractor responsibilities, in general, include, but are not limited to, the following tasks within the Switchyard and Substation (see Appendix A for Owner Furnished Equipment):

1. Dispose of material which is excavated for foundations, provide structural fill and backfill materials, restore rough and finish grade with the specified aggregate materials.

2. Implement a storm water pollution prevention plan (SWPPP) during construction to contain excavation spoils and limit surface erosion.

3. The Contractor will be responsible for restoring the substation surface grade, including rough grading, export of spoils, and import of appropriate fill material as required. Refer to the Site Grading Plan.

4. Furnish and install modifications to the station ground grid, conduits, and pull boxes.

5. Furnish and install precast surface trench systems, including trench systems associated with the low-voltage control cables as shown in the Conduit Plan and Details.

6. Furnish and install station lighting, including task, area, and flood lighting fixtures as identified in the Conduit Plan, Furnish and install a station lighting controller, including a post-mounted interface, and connection to Control Enclosure components.

7. Furnish and install all material for the forming and construction of foundations, oil containment, and support structures for the equipment inside the Substation as shown on the drawings.

8. Furnish, assemble and install the 115 kV switch and bus components, including station post bus support insulators, tubular and cable bus. Note: Switches with insulators for the two (2) new transformer high-side breaker disconnects (Device #1828 and #1928) are being furnished by the Owner. The existing breaker disconnects (Device #1812 and #1821) are to be relocated with their support structures to new Contractor furnished foundations.

9. Install 115 kV manually-operated disconnect switches.

10. Furnish, assemble and install the 115 kV tubular and cable buses, with their associated foundations, support structures, insulators, and bus fittings, providing a high-voltage power connection between each MPT and its high-side high-voltage circuit breaker and breaker disconnect switches. Cable bus jumpers and drops shall be single 954 kcmil AAC.

11. Furnish and install all 12.47 kV outdoor air-insulated switch and bus with high and low tubular buses, cable bus jumpers, including insulators, bus fittings, and support structures with their associated foundations, MPT low-side main circuit breaker and breaker disconnect switches, and distribution circuit feeder bays.

12. Furnish and install a Substation Ground Grid with underground facilities for the grounding of structural steel, circuit breakers, transformers, and shunt capacitor steps; in accordance with the design document package and these specifications.

13. Install One (1) free-standing 15 kV Class 2000 A CC, 25 kA IC, C2 medium-voltage circuit breaker, for use in a MPT low-side Main Circuit Breaker application.

14. Install One (1) free-standing 15 kV Class 2000 A CC, 25 kA IC, C2 medium-voltage circuit breaker, for use in a substitute breaker bay application.

15. Install Two (2) free-standing 15 kV Class 1200 A CC, 25 kA IC, C2 medium-voltage circuit breakers, for use in a distribution feeder bay application.

16. Install One (1) free-standing 15 kV Class 1200 A CC, 25 kA IC, C2 medium-voltage circuit breaker, for use in a shunt capacitor bank bay application.

17. Furnish and install three (3) 4-inch Schedule 80 PVC conduits between each riser structure and the outgoing distribution circuits (a minimum of ten (10) feet outside the Substation fence line) or to an underground vault when shown on the conduit plan drawing. The conduits shall accommodate the outgoing distribution circuit cables, with a continuous operating temperature of at least 90 deg. C. Note, conduits within the fenced area of the Substation which contain medium-voltage power cable, shall have a minimum of six (6) inches on lean concrete "Slurry" cover on their top and sides. The incoming medium-voltage power cables will be Furnished, installed, terminated, and tested by the Owner.

18. Furnish, install, terminate, and test all control and protection wiring associated with the electrical equipment within the substation such as: MPT, 115 kV HVCB's, and 12.47 kV MVCB's.

19. Furnish and install the foundations and structural steel for a multiple step 12.47 kV shunt capacitor bank system. The capacitor bank will be comprised of two (2) steps, sharing a common underground cable connection to the 12.47 kV reactive power support bay. Each step will include a Reactive Switching Devices (RSD), capacitor step block racks (STEP), individual capacitor units (CANS) with their associated current limiting fuses, four-pole grounding switches (4PGRD), neutral voltage transformers (NVT), and a three-phase set of current transformers. The Owner will supply 600 kcmil 15 kV cable and install in the Contractor's conduits. Cable termination will be Furnished and installed by the Owner.

Additionally, the Owner will furnish the Bank 3 capacitor steps with their associated block racks, fuse units, 4-pole Grounding Switches (4PGRD), and Reactive Switching Devices (RSD). Assembly and installation will be performed by the Contractor.

20. Furnish and install the fittings and insulators necessary to terminate the existing suspension buses to the new H-frame deadend structures on the high-side of MPT 2 and MPT 3. Install lightning rods atop each column of the new H-frame deadend structures, with ground conductors as shown in the grounding details.

21. The Contractor will Furnish and install the cable bus drops from the tee tap fittings to the 115 kV "Jack" bus. All cable bus conductors within the Substation shall be AAC.

22. Furnish and install all materials for the MPT 3 oil containment system as shown within the design document package.

23. Furnish and install the lightning protection system. Bond each lightning rod as directed in the Shield Wire Coverage Plan drawing.

24. Furnish, assemble and install all steel structures, towers, poles and other miscellaneous equipment mounting pedestals and equipment supports not specifically supplied with equipment, as shown within the design document package.

25. Provide and install all miscellaneous material not specifically listed as supplied by Owner in this contract, but required to provide for a complete and operational installation. The

Contractor shall supply all labor, supervision, tools, and equipment required for the complete development of the site, construction, testing, and commissioning of the substation.

26. Install all materials and equipment listed as supplied by Owner except that equipment specifically identified elsewhere herein, as installed by either the Owner themselves, the Owner's subcontractor, or the major material Supplier.

27. Install Owner Furnished pre-fabricated control and relay panels

28. Furnish and install SCADA and human machine interface, and station service facilities per technical specifications.

29. Furnish, install, and terminate all low-voltage (2000V or less) control, protection, control power, and station service circuits which are external to the Control Enclosure (field) between the control and relay panels and the originating equipment within the substation yard. The Contractor is responsible for continuity testing and functional/operational verification of all field wired devices and circuits between the originating devices and the control and relay panels. Additionally, the contractor shall verify that the control, alarm, and monitoring functions originating from within the Control Enclosure perform as intended. All multiple conductor cables associated with control and protection systems shall be shielded, with the shield being grounded at the originating equipment only.

30. The Relay Protection Commissioning Contractor (RPC) is responsible for inputting relay settings into the protective relaying devices. The RPC will also perform current and voltage injection testing to verify that the protective relaying device pick-up and drop-out is in accordance with the prescribed settings. These activities will be performed within the relay/control panels, particularly using the test switches installed for this purpose.

31. The Contractor shall verify that MPT electronic temperature monitor (Device 49-T) has been calibrated and programed by the MPT Supplier. The Contractor shall also verify communication path operation, SCADA functions, and alarm functions are implemented and operational.

32. Should it be determined that wiring/device changes are required within the relay/control panels, the RPC will be responsible for making these changes. However, should it be determined that the changes required are outside the relay/control panels, particularly outside the test switches, the Contractor will be responsible for making these changes. The Contractor shall provide assistance to the RPC, particularly where access to the originating devices within the substation yard may be necessary.

33. The distribution system between the Substation conduit risers and the underground vaults outside the fenced area are to be provided and installed by the Owner.

34. The Contractor shall Furnish and install any additional fiber optic termination and fiber management equipment within the Control Enclosure vault and/or cabinets, which has not been Furnished and installed by the Owner.

5.3 PERMITS AND INSPECTIONS

The Contractor shall obtain all construction permits required to perform the work as described herein. All inspections required by local, state, or federal authorities shall be arranged and scheduled by the Contractor. All permits required shall be posted at the substation site or be available for review and inspection by the Owner or authorities.

5.4 CONTRACTOR FURNISHED MATERIALS

Contractor shall Furnish all materials necessary to complete the work and provide for a complete and operational system, except for materials listed above as "Owner Furnished". Below is a partial list of material items which are to be Furnished by the Contractor. This list is not intended to be complete or all inclusive.

1. All steel structures including the fabrication and galvanizing of the following steel structures:

- Pre-engineered steel structures used for 115 kV "Jack" bus high and low bus supports.
- 115 kV H-frame deadend and disconnect switch support, and 12.47 kV open-air switch and bus support structures.
- 115 kV transformer high-side bus support.
- Pre-engineered steel structures used for 12.47 kV shunt capacitor bank steps, including conduit risers / bus support structures.
- Pre-engineered steel structures used for 12.47 kV station service transformers and fused cut-outs associated with Bus Sections 1 and 3.
- Pre-engineered steel structures used for 12.47 kV Main Breaker disconnects, MPT low-side main buswork, and station service transformers and fused cut-outs.
- Switch operator platforms.

2. Concrete and all associated materials for protection and curing of concrete, including form lumber, form materials, steel reinforcement, anchor bolts, and coating. Refer to section on Concrete for concrete specifications.

3. Aluminum tubular bus fittings, including bolted and welded fittings, shall be supplied by the following approved manufacturers:

Hubbell (Anderson)
AFL (Dossert)
Thomas & Betts (Homac)
Travis Pattern and Foundry

4. Aluminum cable bus fittings are to be compression type unless noted otherwise in the bill of material. Cast aluminum compression fittings are not allowed. Cable fittings shall be machined from aluminum extruded tube or bar stock, and are to be supplied by the following approved manufacturers:

DMC Power (Deutsch)
Fargo (Hubbell)

5. Welded tubular bus fittings may be replaced with compression fittings manufactured only by DMC Power (Deutsch), installed with their radial compression die system at the Contractor's discretion.

6. Welding gas, aluminum filler, wire or rods, and other materials for welding aluminum tubular bus.

7. Materials for grounding, including materials for alloy brazing or making exothermic weld connections for below ground bonding, mechanical connectors for above ground bonding to structural steel, switch and bus equipment, fencing, copper braids for gates, and copper-clad material for fence and perimeter grounding.

8. Below grade ground grid connects shall only be made using exothermic welded type connections, except as noted below. Exothermic weld molds and materials shall be supplied by the following approved manufacturers:

Erico
ThermOweld

9. Welded ground fittings may be replaced with compression fittings manufactured by DMC Power (Deutsch) as a sole source, installed with DMC Power's radial compression die system and tools, at the Contractor's discretion.

10. Grounding pigtail 2-hole pad connections to structural steel columns are to be made using either exothermic weld offset 2-hole terminal pads or DMC Power compression connectors. Applications which require the grounding conductor to extend beyond the structure ground pad, such as overhead shield wire and surge arrester ground connections, may ground the structure using a bolted type fitting to allow the grounding conductor to be continuous.

11. Equipment mounting hardware, including the hardware required to mount the air-break disconnect switches to the structures, and including cap screws and lock washers for station post insulators.

12. All fencing fabric, posts, rails, brackets, barbed wire, gates, and miscellaneous hardware required to install the perimeter fencing around the substation.

13. All road rock, pit run, yard surfacing rock, and backfill material as specified in the section addressing Site Work.

14. Galvanized steel conduit, straps, support hardware and conduit fittings (i.e., bushings, locknuts, reducers, nipples, outlet boxes, clamps, strut material etc.), including junction boxes and mounting brackets.

15. UL Listed PVC conduit, conduit elbows, straps, support hardware and conduit fittings (i.e., couplers, end bells, caps, etc.), cement, cleaning solvent, and other miscellaneous items required for the installation of the conduit system for the Substation.

16. Low-voltage (2000V and below) cabling, for low-voltage power and control applications, including single conductor and multi-conductor cables, shielded cable, and materials for termination of individual conductors, control cables and inter-panel wiring, including compression terminal lugs, plastic ties for wire bundling, cable number tags, and electrical tape, solder, or pressure connectors for joints and splices, heat shrink wire labels, and other items required to install and connect the low-voltage electrical system.

17. Miscellaneous items, such as soil sterilizer, screws, bolts, cable pulling compound, compression fitting filler compound, duct sealant and electrical joint compound. Refer to section on Site Work for material specifications.

18. Substation luminaires, brackets, poles, and lamps as shown on the drawings.

19. Construction water, if necessary, and potable water, construction power and sanitation facilities.

20. All equipment and materials as identified in the outdoor substation bill of materials as listed on drawings and not identified as supplied by Owner, such as insulators, station service transformers, fittings, etc.

21. 12.47 kV Bus Sections 2 and 3, 3-phase set of bus potential devices, with primary fused disconnects, and secondary fused cut-outs.

5.5 STATION EQUIPMENT INSTALLATION

The Contractor shall Furnish all labor, tools, and equipment necessary to install all materials and equipment as provided by Contractor and Furnished by the Owner, except for the Main Power Transformer(s), in accordance with the specifications herein and as shown on the drawings.

The following pieces of selected equipment and their approximate weights, are listed for Contractor's information only and will be off-loaded and placed on the Contractor provided foundation by the Supplier of the equipment: Main Power Transformer(s), dressed and filled with oil, 190,000-pounds each.

5.6 MATERIALS NOT INCLUDED

The distribution circuit home run cables, with fiber optic cable and subduct, of sufficient length to terminate within the Substation, will be Furnished by the Owner.

5.7 RESPONSIBILITY FOR EQUIPMENT AND MATERIALS

Contractor shall be responsible for the receiving, transportation, storage and final placement at the jobsite of all Contractor and Owner Furnished materials except as identified elsewhere herein. Major material items provided by the Owner may be held in storage prior to the commencement of construction. The Contractor shall be responsible for transference of these items from storage to the jobsite as they become needed.

During performance of the Work, the Contractor is responsible for the security, protection from the weather (if needed) and proper storage of all related equipment and/or materials that the Contractor supplies as part of the performance of the Work until turnover and acceptance of the Work by the Owner. The Contractor shall also be responsible for the security, protection from the weather (if needed) and proper storage of the Owner supplied materials when given to the Contractor for installation or use within the Contractor's scope of work.

The Contractor shall provide a construction laydown area as close to the Substation site as possible for the storage of equipment, materials, and tools. This laydown area shall be covered with compacted gravel and properly drained to facilitate access to equipment stored in the laydown area for all weather conditions. Refer to the Site Plan for the area to be developed for laydown and parking.

5.7.1 Material Delivery and Receiving

The Contractor shall provide the necessary equipment and personnel required to unload, store and protect materials (except main power transformers and switchgear/control enclosure) delivered to the jobsite. The Contractor shall take all precautions necessary to protect all received materials from soiling, disfigurement or damage when unloading.

The Contractor shall promptly inspect material shipments to determine product quantity, type, and general compliance with material purchase orders.

The Contractor shall record and catalog all received materials including Owner Furnished materials. Contractor shall notify Owner's Representative of receipt of all Owner Furnished materials or equipment and materials received for others, if required. When receiving any materials for others, including Owner Furnished material, Contractor shall specifically identify the materials received, and for whom the materials intended, carefully noting the condition when received. The Contractor shall not receive any materials or equipment except that which the Contractor has ordered or which is supplied or Furnished by Owner and identified herein, unless specifically requested in writing by the Owner.

Materials and equipment shall be stored with seals and labels intact and visible for easy retrieval and inspection at a later date. All materials and equipment shall be stored per Manufacturer's instructions. Unlike materials shall not be stacked.

The Contractor shall supply tarps, enclosures, containers, totes, heaters, or any other devices to prevent materials and equipment from being damaged by sun, rain, snow, dust or other deleterious conditions.

The Contractor shall supply facilities to store sensitive products in a weathertight, climate controlled environment such as a sea van, as required.

5.7.2 Equipment Retrieval and Distribution

The Contractor shall maintain adequate material tracking records to determine their status. When materials are to be distributed to work areas, the Contractor shall provide equipment and personnel to load and transport equipment and materials to their point of use.

The Contractor shall immediately notify the Owner if Owner supplied materials or equipment are misplaced or damaged. When Owner supplied materials or equipment is removed from the storage site for use, the Contractor shall notify the Owner that the materials or equipment are no longer being stored at the storage site.

5.8 COOPERATION WITH OTHERS

The Contractor shall fully cooperate and coordinate with other contractors and Manufacturer's personnel who may be awarded other work. The Contractor shall exchange with the various contractors and manufacturers all necessary drawings, dimensions, templates, or other information to insure the complete and proper installation of connections or related parts of the wind project collector substation. The Contractor shall not commit or permit any act which will interfere with the performance of work by other contractors or equipment suppliers. No extra compensation shall be claimed because of any modifications required to accommodate equipment of other manufacturers, except as otherwise specifically stated herein. All adjustments shall be made between the respective contractors without involving extra cost to the Owner.

6.0 Site Work

The substation site is to be stripped (typically the top 6-inches of topsoil) of major vegetation, including root systems, prior to beginning the grading work. The site topography should be assumed to be as shown on drawing. The Contractor is responsible for transport and disposal of the vegetation/top soil being removed in preparation for grading, cutting, and filling. Excess cut material (below the top 6-inches of vegetation/top soil), and material removed for foundations, may be stockpiled during construction, and any unused material shall be hauled off prior to commissioning the facilities.

The Contractor shall diligently maintain any and all benchmarks, monuments, and other reference points located by the Contractor or others during the course of this work.

If utilities, old concrete foundations, or other, abandoned materials are encountered during site excavation, they should be rerouted if active, or properly abandoned. Abandonment requires removal and backfill with granular materials, compacted as structural fill.

Snow removal at the site shall be the Contractor's responsibility. The Contractor shall perform snow removal promptly and efficiently by means of suitable equipment whenever necessary for safety. Any removed snow piled around the worksite shall not interfere with the operations of other contractor's that may also be working at the site. Piled snow shall not restrict access by any vehicles to or at the site, especially emergency vehicles.

If during excavation hard rock is discovered, the Contractor shall notify the Owner to discuss options prior to continuing work. If it is determined that blasting is required, it will only be permitted after receiving approval to do so from the Owner.

All construction shall be done in a thorough and workmanlike manner in accordance with local jurisdictions, Owner Furnished specifications, construction drawings and details, and applicable industry standards.

6.1 SURVEYING AND GRADING

The work to be performed by Contractor shall include all labor, material, equipment, and transportation necessary to strip top soil, to grade the substation area, and to provide all surveying work necessary to maintain the lines, grades, and elevations required and shown on the drawings.

6.1.1 Surveying

Contractor shall set up temporary north-south and east-west baseline markers outside the area to be graded so they will not be disturbed. Contractor shall set necessary cut and fill stakes.

After grading, the Contractor shall establish and maintain horizontal and vertical references for locating all footings, foundations, other subsurface structures, fence lines, and substation equipment during construction.

Survey precision shall be within 0.1-feet for purposes of grading, and 0.01-feet for top of foundations. Horizontal precision shall be sufficient to assure ease of erection of structures and placement of substation equipment.

6.1.2 Rough Grading

Rough grading shall include all necessary excavation below the original top soil layer and placement of structural fill material to attain substation grades and elevations shown within the design document package. This grade elevation is referred to in the design document package as "Rough Grade" to differentiate it from "Finish Grade", which is the final grade elevation after all below grade installation has been completed and the top layer (typically 4-inches) of finish rock has been installed.

Excavation work shall include the removal and subsequent handling of all soil materials excavated or otherwise removed in performance of excavation work. Contractor shall provide adequate protection of excavated side slopes to protect all personnel and to prevent sloughing into the work area.

Prior to structural fill placement, the exposed native soils shall be uniformly scarified to a minimum depth of 6-inches.

Contractor shall haul excavated material or any debris deemed unsuitable for structural fill to an offsite disposal location as directed by Owner.

6.1.3 Fill

6.1.3.1 Structural Fill

Fill material, defined as Structural Fill on the project drawings and herein, may consist of material excavated within the substation site or property lines, or may be imported material, or be a combination of both.

Structural fill shall be clean and free of vegetation, pieces of timber, or other foreign material. No material shall be placed when either the material placed, or material on which it is placed, is frozen.

Structural fill shall be deposited in horizontal layers (lifts) having a thickness of not more than 6-inches before being compacted. Each lift shall be conditioned to near optimum moisture content and compacted to a dry density equivalent to 95% of the maximum dry density obtainable by the Modified Proctor ASTM D-1557.

As an alternate to compacted structural fill, the Contractor may substitute flowable fill (2-sack lean concrete with a minimum compressive strength of 1800 psi). This same material may also be used as back fill around formed foundations, except the transformer containment walls.

6.1.3.2 Imported Fill

Imported fill material shall be uniformly graded granular material with a maximum particle size of 1-inch. Material shall have sufficient fines to fill all voids and to assure compatibility. The portion of the imported material passing the #4 sieve shall have a maximum Liquid Limit of 30 and a maximum Plasticity Index of 6. Contractor shall submit gradation (AASHTO T27), Liquid Limit (AASHTO T89) and Plasticity Index (AASHTO T90) test results to Owner for approval prior to placing.

6.1.3.3 Pit Run

Material generally described as Pit Run shall conform to ASTM D-2487 soil classifications GW, GP, SW, and SP. Pit Run shall be free of rock or gravel larger than 4-inches in any dimension, with less than 10% passing the 200 sieve and shall be free of excess moisture, debris, waste, frozen materials, vegetation, and other deleterious matter.

6.1.3.4 Testing

Contractor shall employ, if required by Owner, an approved independent testing laboratory to perform compaction tests. All results shall be submitted to Owner.

6.2 SURFACING

Contractor shall Furnish all materials and shall provide all labor, tools, and equipment necessary to place and compact crushed rock surfacing material in the substation and in areas outside the substation fence, as shown on the drawings and as specified herein, and to sterilize the soil within the surfacing area.

6.2.1 Soil Sterilization

Only areas to be surfaced with finish rock (including the areas outside the station fence), shall be treated with a weed eradicator and soil fumigant.

The weed eradicator and soil fumigant used, shall be one of the following products: Allied Chemical UROX or URAB, DuPont Hyvar-X, Hyvar-XL, or Krovar-I. Application shall be in strict accordance with the Manufacturer's instructions.

Extreme care shall be exercised in the application of the soil sterilant where there is danger of contaminating adjacent seeded areas, shrubs, trees, or neighboring property. Contractor shall be held liable for any plant damage due to the use of the soil sterilant.

6.2.2 Surfacing Material

6.2.2.1 Subgrade Material

The location and depth of the subgrade shall be as specified in the notes of the Grading and Drainage plans.

If unsuitable fill is encountered in areas being excavated for foundations, backfill with pit run.

Subgrades shall be constructed with pit run that will produce the finished grade elevations plus or minus 0.10-feet as shown on the drawings with special attention to proper drainage. Subgrade fill shall be compacted in 6-inch lifts or less to obtain a dry density equivalent to 95% of the maximum dry density obtainable by the modified Proctor ASTM D-1557.

After proper compaction, the graded area shall be shaped and fine-graded as shown on the drawings. The accumulation of loose material incidental to fine grading shall be incorporated into the subgrade by means of pneumatic tire roller or other suitable available means of compaction.

6.2.2.2 Road Base Rock

Aggregate Base Course material shall be sound, hard, durable crushed rock uniformly graded from coarse to fine. The aggregate shall conform to the following specifications unless otherwise approved by the Owner.

US Standard Sieve	Percent Passing
3-inch	100
2-1/2-inch	95-100
1-1/4-inch	55-75
1/4-inch	30-45
#10	15-25
#200	less than 15

6.2.2.3 Road Finish Rock

Road Finish Rock material shall be sound, hard, durable, crushed rock uniformly graded from coarse to fine. The aggregate shall conform to the following specifications unless otherwise approved by the Owner.

Gradation (per AASHTO T 27)	
US Standard Sieve	**Percent Passing**
1-1/2-inch	100
1-inch	90-100
1/2-inch	55-75
1/4-inch	40-55
200	less than 5
Sand Equivalent (per AASHTO T 176): Not less than 30	

Fractured Face: Provide at least one mechanically fractured face for a minimum of 50% of particles retained on the 1/4-inch sieve.

Road Finish Rock material shall be placed on areas designated on the drawings for roadways or parking. Prior to placing road finish rock, the subgrade shall be smoothed and compacted to required specification. Finish rock shall be placed in uniform layers not to exceed 6-inches in loose thickness, for the entire width of the road surface. Each layer of road finish rock shall be completed, leveled and uniformly compacted before the succeeding layer is placed. Water shall be added or removed, as necessary, in order to obtain the required density. Each lift shall be conditioned to near optimum moisture content and compacted to a density equivalent to at least 92% of the maximum dry density obtainable by the ASTM designation D-1557. In place field density shall be measured in accordance with ASTM D 1556 or ASTM D 2922.

6.2.2.4 Yard Finish Rock

Yard Finish Rock used to surface the substation yard as shown on the drawings shall be sound, hard, durable, clean angular crushed rock. The rock shall meet the following criteria:

US Standard Sieve	Percent Passing
1-inch	90-100
3/4-inch	50-80
3/8-inch	15-40
No. 4	0-10

Yard Finish Rock shall be evenly spread on the designated areas of the yard as shown on the drawings. Depth of Yard Finish Rock shall be 4-inches or as shown on the drawings. Surface of Yard Finish Rock shall be free from corrugations or waves. The Yard Finish Rock shall also meet the electrical resistivity requirements outlined in the Grounding Plan, Drawing PRW-E-230.

6.2.2.5 Material Approval

Contractor shall make every effort possible to provide material that complies with the specifications. Owner will review alternate sizes and gradations if those specified are not available in the area.

Contractor shall obtain the approval of Owner for finish rock materials at least seven days prior to delivery and placement. Any finish rock delivered to the site of the work, which does not meet with the approval of Owner, will be rejected.

The results of gradation (AASHTO T-27) tests and a sample of the crushed rock shall be Furnished to Owner prior to obtaining approval of rock materials.

Any soil materials found in the ASTM D-2487 soil classification groups MH, CH, OL, OH or PT is considered an unsatisfactory soil material.

6.2.2.6 Placement

Surfacing material shall not be placed on snow, frozen subgrade, uncompacted fills, or soft mud. Surfacing material shall be placed after all footing and underground work within the substation yard has been completed.

Compaction of base rock shall be done with a wheel or shoe vibratory compacter sized for roadway base compacting. Base rock shall be deposited in horizontal layers having a thickness of not more than 6-inches before being compacted. Each lift shall be conditioned to optimum moisture content and compacted to a dry density equivalent to at least 95% of the maximum dry density obtainable by the ASTM Designation D-1557.

Depth of finish rock shall be 4-inches. Surface of finish rock shall be free from corrugations or waves.

6.3 ACCESS ROADWAYS AND INTERIOR ROADWAYS

Interior roadway areas as shown on the substation drawings that are an integral part of the substation shall be the responsibility of the Contractor as well as the entrance approach at each gate and entrance road from highway.

6.4 FENCING

The work to be performed involves adding new chain-link substation fencing and gates. Fence installation shall be as shown on the drawings and as described herein.

6.4.1 Station Fence and Gates

Contractor shall Furnish all materials, labor, tools, and equipment necessary to install the new station fence, as shown on the Fence Details drawing for the substation. Note that the common fence shared with the switching station is not included in this specification.

Contractor Furnished materials shall comply with the material specifications on the Fence Details drawing.

The chain link fence shall be installed in compliance with the erection requirements as shown on the Fence Plan and this technical provision. Installation shall be made by individuals experienced in the erection of this type of fence.

Foundations for posts shall be concrete with the top 6-inch formed. If ground is firm enough to permit excavation of the posthole to neat lines, the concrete may be placed without forms. The top of the concrete around the steel fence post shall be crowned toward the post to prevent water from standing on top of the concrete and around the steel post.

Ready-mix concrete shall have a minimum 28-day compressive strength of 3000 psi, air content of 4-1/2% to 7-1/2%, and water-cement ratio at time of placement of 0.53 by weight. Site-mixed concrete shall be 1:2:4 mix (1 cement, 2 sand, and 4 gravel). Maximum slump for ready mix or site mixed concrete shall be 4-inches.

Where solid rock is encountered, the Contractor will drill a hole 2-inches larger than the post diameter, and the post will then be grouted into the hole with a fine mix of concrete. Minimum depth of holes in solid rock shall be 12-inches for line posts and 18-inches for corner, gate, and fabric tensioning pull posts. Where solid rock is covered with an over burden of soils, the posts shall be set in the solid rock to the depth noted above and the upper portion of the holes shall be completed as a standard concrete footing.

Concrete above ground must be kept moist to sustain the proper chemical reactions for curing. No concrete shall be poured if the ambient temperature will be less than 35 deg. F unless provisions are provided to insulate the pipe and the concrete for a minimum of 72-hours from the freezing ambient temperatures.

Gate aprons shall be installed as detailed on the drawings. The aprons shall be installed in such a manner as to provide a space of no more than 4-inches between the bottom rail of the gate and the finished top of the apron.

6.5 ENVIRONMENTAL REQUIREMENTS

6.5.1 Disposal of Hazardous Materials

In all its operations under this Contract, the Contractor shall comply with all applicable federal, state, and local laws and regulations concerning the use, storage, transportation, and disposal of hazardous materials. Toxic or hazardous material shall not be released onto the ground or into any dry drainage features. These substances include, but are not limited to, herbicides, fumigants, rodenticides, petroleum products, and solvents. Contractor shall take immediate action to mitigate the effects of an accidental spill of any hazardous material. Contractor shall notify the Owner as soon as practical, and in no case later than 24-hours after such an event.

6.5.2 Erosion Control

Construction operations shall be conducted to prevent any unnecessary scarring or defacing of the natural vegetation and surroundings in the vicinity of the work. Construction methods shall be designed to limit, so far as reasonable, erosion or subsidence. The Contractor shall take such soil and resource conservation and protection measures that the Owner determines necessary. Temporary and permanent sediment and erosion controls shall be installed and maintained when performing any ground disturbing activities. These controls shall include silt fences, hay bales, earthen dikes, drainage swales, sediment traps, sediment basins, and similar measures. Sediment escaping the site during construction must be removed on a regular basis to minimize offsite impact.

6.5.3 Environmental Regulations

Contractor shall conduct all construction activities in a manner that will minimize degradation of air, land, and water quality. All construction work and subsequent use of the job site must be consistent with applicable federal, state, and local standards relating to safety, environmental quality, and public health. All garbage, debris, and other foreign matter shall be removed to an established sanitary landfill or other recognized disposal facility. No open burning of trash or debris at the substation is allowed.

6.5.4 Dust Control

The designated access roads and the soils in all other areas within the construction limits will be watered, as needed, to remain compact and to avoid the creation of dust. Contractor shall have a water truck available on site during construction for dust control, as appropriate. This may also require the limitation of types of equipment, vehicle speeds, and routes utilized. Water, straw, wood chips, dust reducer, gravel, or a combination of these or similar control measures may be required by the Owner.

6.5.5 Site Access Roads

All construction activities will be restricted to designated access routes. Deviation from designated roads will not be allowed without prior approval from the Owner. Designated access routes are indicated on the project maps. Improvements to the access roads to the site are by others. If the Contractor damages the access roads with equipment or vehicles, the Contractor shall be responsible for repair.

6.5.6 Fire Prevention

All federal, state, and county laws, ordinances, rules, and regulations, which pertain to prevention, pre-suppression, and suppression of fires, shall be strictly adhered to. Contractor shall advise all personnel of their responsibilities under the applicable fire laws and regulations. It shall be the responsibility of the Contractor in the event a project related fire occurs within or adjacent to the construction area, to immediately take actions to contain or control its spread and concurrently to notify the local authorities. Contractor shall notify the Owner as soon as practical, and in no case later than 24-hours, in the event of a fire.

The Contractor shall be responsible for any fire started by its employees or operations, in or out of the project area during construction, and for fire suppression and rehabilitation. The Contractor shall take aggressive action to prevent and suppress fires on and adjacent to the project area, and will utilize its workers and equipment on the project for fighting fires within the project area.

The BLM, the US Forest Service, or the State of Minnesota may call on the Contractor's workers and equipment in emergencies for fires outside the project area. Payment for labor and equipment shall be negotiated between the Contractor and the federal and/or state agency.

Costs involved with Contractor-caused fires will be the responsibility of the Contractor. There will be no extension of time for delays caused by Contractor-related fires.

Specific construction-related activities and safety measures shall be implemented during construction of the substation in order to prevent fires and to ensure quick response and suppression in the event a fire occurs. These activities and requirements include:

- All vehicles must stay on designated roads or parking areas free of vegetation.
- Vehicles, gas-powered equipment, and flues shall be equipped with spark arrestors.
- The Contractor shall provide and store in a place easily accessed at each construction site five shovels, two backpack pumps with water, and one five-pound ABC rated dry powder CO2 fire extinguisher during all construction activities.
- All vehicles shall be equipped with at least one fire extinguisher.
- Contractor shall have emergency contact notification numbers readily available for all employees in case of fire

6.6 CLEANUP DURING CONSTRUCTION

The construction site and contractor laydown area(s) shall be kept in a neat and orderly condition, as stipulated below. The Owner may, at any time during construction, order a general cleanup of the site as a part of the work under this section. Such cleanup shall not result in any additional cost to the Owner.

Wire clippings, bundle ties, nails, conduit, scrap forming materials, and other metallic scraps are to be picked up and placed in appropriate waste containers.

All garbage, lunch wraps, equipment parts, oil filters, petroleum products, and light packaging material such as plastic, paper and cardboard are to be removed from the site on a daily basis. The Contractor shall dispose of waste, trash, and debris in a manner acceptable to the Owner.

After completion of construction, all construction debris, and leftover materials shall be removed by the Contractor. Prior to final inspection by the Owner and after all construction work is essentially complete, the Contractor shall thoroughly cleanup work staging areas, material storage areas, structures and facilities, access areas, and all other sites and facilities associated with the construction site.

6.7 WORK NEAR ENERGIZED LINES

The Contractor shall provide warning signs in work areas where energized overhead lines are encountered. The Contractor shall provide training to all personnel and all venders under the control of the Contractor that will instruct personnel and vendors of the proper procedures for working near the energized high voltage lines.

The Contractor shall submit the training program documentation to the Owner before any work begins at the site. The Contractor's training program will identify the hazards, procedures for working near the energized lines and emergency actions and response should a piece of equipment or personnel make contact with the line.

7.0 Concrete Footings and Foundations

7.1 MATERIALS

Contractor shall Furnish all material required, including all reinforcing steel, bar supports, ties, spacers, inserts, and other concrete accessories. Contractor shall provide all labor, tools, and equipment necessary to excavate for and construct all footings and foundations as described in this specification and as shown on the drawings.

7.2 CODES AND STANDARDS

Contractor shall comply with the provisions of the latest edition of the codes, specifications, and standards as referred to in Publications, Certifications and Practices section of these specifications.

Contractor-Furnished materials shall comply with the Contract and shall meet the requirements of the following specifications:

Admixtures	Air-Entraining (Required)	Standard Specification for Air-Entraining Admixtures for Concrete, ASTM C-260
	Water-Reducing (Optional)	Standard Specification for Chemical Admixtures for Concrete, ASTM C-494
	Plasticizers (Optional)	Applicable ASTM Specifications
	Calcium Chloride	Not Allowed
Aggregate	1-inch maximum size coarse aggregate. Aggregate proportioning shall be no more than 45% fine aggregate to 55% coarse aggregate. Clay or shale particles passing the 200 sieve shall not exceed 1%.	
Anchor Bolts	ASTM A36 or ASTM F1554 Grade 36. Bolts shall be hot-dipped galvanized per Standard Specification for Zinc Coating Hot-Dipped on Iron and Steel Hardware ASTM A-15. Bolt diameter, length, thread length, other details are as shown on the drawings.	
Cement	ASTM C-150, Standard Specification for Portland Cement, Type II	
Concrete	All concrete shall obtain a minimum 28-day strength of 4000 psi. Concrete shall be proportioned and produced to have a slump of 5-inches or less and shall be made with a minimum of 6.3 sacks of cement per cubic yard. All concrete shall contain an air entrainment admixture. Total air content by volume, at the time of placement, shall be maintained at 6% plus or minus 1-1/2%. The water-cement ratio at the time of placement shall not exceed 0.53 by weight. The mix design shall be submitted for approval and shall comply with Chapter 5 of ACI-318-05.	

Fly Ash (Optional)	Reinforced concrete may incorporate the use of fly ash, properly proportioned to maintain the specified minimum compressive strength. All fly ash shall meet, as a minimum, the Standard Specification for Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete ASTM C-618, Class F or Class C fly ashes. However, in addition, all fly ash shall be limited to the following respects: The maximum loss on ignition shall not exceed 1%. The maximum amount retained when wet-sieved on a #325 sieve (i.e., fineness) shall not exceed 25%. The amount of Portland cement that can be replaced by fly ash shall not exceed 20% by weight of cement.
Form Coating	Industrial Lubricants Nox-Crete Form Coating, L&M Debond, Protex Pro-Cote, Richmond Rich Cote, or approved equivalent
Form Material	Plywood and fiberboard materials which are free of damage, cracks, weathering, or any defect which would prohibit the formed surface from appearing smooth and uniformly textured.
Nuts	Standard Specification for Carbon and Alloy Steel Nuts ASTM A-563. Nuts shall be hot-dipped galvanized per ASTM A-153. Nuts shall be tapped out oversize prior to galvanizing (1/32-inch for 3/4-inch and larger --- 1/64-inch for 5/8-inch and smaller). Ship nuts assembled on anchor bolts to assure finger ease fit. Each anchor bolt shall be provided with three (3) nuts.
Reinforcing Bar Supports	Fabricate from galvanized wire. Plastic coated or tipped for use in contact with forms for exposed surfaces
Reinforcing Steel	Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement, ASTM A-615, Grade 60
Embedded Steel	All embedded steel, shall conform to the requirements of ASTM Designation A-36, as revised to date. All corrections for angularity, straightness, and flatness to meet fabrication requirements shall be made. All structural steel shall be hot-dipped galvanized after fabrication in accordance with ASTM Designation A-123.
Washers	Standard Specification for Hardened Steel Washers ASTM F-436, Type I. One washer shall be provided with each anchor bolt.
Water	Clean and free from mud, oil, organic matter or other deleterious substances

7.3 INSTALLATION

Contractor shall install reinforced concrete footings and foundations in accordance with the following provisions:

7.3.1 Prerequisites

Prior to the start of excavating, Contractor shall make the preparations listed below:

Construction drawings shall be thoroughly reviewed. The locations of underground facilities shall be noted and marked to avoid damage occurring during foundation construction activities.

A site inspection shall take particular note of ground and storm water conditions and the extent to which they may affect foundation excavation.

Baselines, construction stakes, and horizontal and vertical reference points shall be established by Contractor before excavating for footings and foundations. Contractor shall assume full responsibility for dimensions and elevations measured from construction stakes.

7.3.2 Excavation

Contractor shall excavate for footings to the depth shown on the drawings, unless greater depth is required to obtain suitable bearing. Excavations shall be kept free of water during placement of forms and concrete, and while working below grade.

As required, Contractor shall supply and install temporary sheeting or shoring as set forth in the rules, orders, and regulations of the United States Department of Labor Occupational Health and Safety Administration (OSHA).

Side slopes shall be excavated to an acceptable safe angle of repose, consistent with the type of material being excavated.

7.3.3 Forms

Forms shall be designed to produce hardened concrete having the shape, lines, and dimensions shown on the drawings. Forms shall be constructed and maintained in proper position and accurate alignment.

Forms shall not be removed or disturbed until the concrete has attained sufficient strength to safely support all dead and live loads to be imposed thereon.

Formwork supporting weight of concrete may not be removed in less than 7 days.

Form facing material may be removed two days after placement, if concrete has attained enough strength to support designed loads and if shores and other vertical supports have been arranged to permit removal of form facing materials without disturbing shores.

Do not pry against concrete surface during formwork removal.

7.3.4 Embedments

Embedments shall be accurately positioned and securely anchored. Embedments shall be clean when they are installed. After installation, surfaces not in contact with concrete shall be cleaned of all concrete spatter and other foreign substances.

7.3.5 Anchor Bolts

Anchor bolts shall be accurately located to within 1/16-inch of their design locations prior to placement of concrete.

Concrete shall be placed so as not to tilt or laterally displace the anchor bolts (i.e., vibrators may be used to consolidate concrete but shall not be used to transport it laterally within the forms).

Welding shall not be permitted on anchor bolts unless specifically required on the design drawings.

Enlargement of base plate anchor bolt holes or bending of anchor bolts shall not be permitted.

All other bolts and nuts shall confirm to ASTM A-307 unless otherwise specified on the drawings.

7.3.6 Voids

Voids in sieves, inserts, and anchor slots shall be filled temporarily with readily removable material to prevent the entry of concrete into the voids.

7.3.7 Reinforcement

Reinforcing steel shall be placed as shown on the drawings.

Reinforcing steel may be moved as necessary to avoid interference with other reinforcing steel, conduits, or embedded items. Maximum steel spacing shall not be exceeded, however.

At time of placing, the reinforcing steel shall be free from loose mill scale, flaking rust, mud, oil, grease, or paint.

Reinforcing steel deformed bars shall be tied with steel wire to maintain the spacing shown on the drawings.

Lap splices in welded wire fabric shall be so made that overlap between outermost cross wires of each fabric sheet is not less than the spacing of the cross wires plus 2-inches.

Welding of reinforcement for any purpose, and tack welding in particular, is expressly prohibited.

Reinforcing steel lap, hook and embedment lengths shall conform to ACI 318 or as shown on the drawings.

7.3.8 Concrete Placement

Contractor shall inspect reinforcing steel and see that it is free of deleterious rust, oil, dust, mud and other coatings before concrete is placed. All surfaces that may have become encrusted with dried mortar or concrete from previous placement operations shall be cleaned.

Concrete shall be conveyed to the point of deposit by methods that shall prevent the separation or loss of material. Equipment for chuting, pumping, and pneumatically conveying concrete shall allow for a continuous flow of concrete at the delivery end without separation of materials. Ready-mix delivery time shall conform to ACI-304. Batch mixes shall be discharged completely within 90- minutes of addition of water to aggregates.

Concrete shall not be placed against or on top of frozen ground, snow, ice, or water. The subgrade shall be sufficiently moist when concrete is placed to eliminate water loss from the concrete.

Concrete shall not be allowed to free fall more than 8-feet during placement. Concrete shall remain plastic during pour. No re-tempered concrete shall be used. All pours shall be continuous.

Concrete must be thoroughly compacted by suitable means and shall be worked to fill the form completely. Vibrators shall be used and shall be maintained at a vertical position. Care shall be exercised to avoid excessive contact of the vibrating head with surfaces of the forms and embedded items.

Unless otherwise specified on the drawings, the minimum concrete protective covering of reinforcement for slabs and footings, if concrete is placed against the ground, shall be 3-inches, and 2-inches if concrete is placed against formed edges.

7.3.8.1 Weather

Cold Weather: When the temperature of the surrounding air is expected to be below 40 deg. F during placing or within twenty-four (24) hours thereafter, concrete shall be placed in accordance with the recommendations of ACI-306 Cold Weather Concreting. Adequate equipment shall be provided for heating concrete materials. All concrete materials, reinforcement forms, fills, and ground that the concrete is to come in contact with shall be free from frost. No frozen materials or materials containing ice shall be used.

Hot Weather: During period of hot weather, or when the combination of hot weather, low relative humidity and wind velocity will tend to impair the quality of the concrete, concrete shall be placed and cured in accordance with the recommendations of ACI-305 Hot Weather Concreting. No concrete shall be placed when the temperature of the concrete exceeds 90 deg. F prior to placement. Concrete delivered to the job site, which exceeds 90 deg. F, shall be wasted.

7.3.9 Curing

Concrete shall be protected from premature drying, excessively hot or cold temperatures, and mechanical injury. Concrete shall be maintained with minimal moisture loss at a relatively constant temperature for at least seven days, except high-early-strength concrete, for which the period shall be at least three days.

For concrete surfaces not in contact with forms, one of the following procedures shall be applied immediately after completion of placement and finishing:

Application of absorptive mats or fabric kept continuously wet.

Application of waterproof sheet materials, securely anchored to prevent drying of concrete from wind damage.

Application of a curing compound conforming to Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete ASTM C-309. The compound shall be applied in accordance with the manufacturer recommendations immediately after any water sheen that may develop after finishing, has disappeared from the concrete surface.

Moisture loss from surfaces placed against wooden forms or metal forms exposed to heating by the sun shall be minimized by keeping the forms wet until they can be safely removed. After form removal, the concrete shall be cured for the balance of the 7-days by one of the methods prescribed above.

Proper attention shall be given during curing to prevent excessive concrete temperatures, or water evaporation that will impair the required strength or serviceability of the structure.

When the temperature of the surrounding air is expected to be below 40 deg. F, concrete shall be cured in accordance with the recommendations of ACI-306 Cold Weather Concreting. Adequate equipment shall be provided for protecting the concrete during curing. Combustion heaters are not allowed for heating for the first 24-hours after concrete placement unless precautions are taken to prevent exposure of the fresh concrete to combustion gases.

7.3.10 Finish

Slab foundations shall be steel trowel finished as follows: The first troweling after floating shall produce a smooth surface which is relatively free of defects, but which may still show some trowel marks. Additional troweling shall be done by hand after the surface has hardened sufficiently. The surface shall be thoroughly consolidated by the hand troweling operations. The finished surface shall be free of trowel marks, uniform in texture and appearance, and shall be plane to within 1/8-inch in 10-feet or proportional amounts for foundations smaller than 10-feet. Top of foundations shall be within plus or minus 1/8-inch of elevation shown on the drawings. Unless specified to be beveled, exposed edges of floated or troweled surfaces shall be edged with a tool having a 3/8-inch corner radius. Tops of spread footings (below grade) shall be wood trowel finished.

7.3.10.1 Repair of Surface Defects

Surface defects, including tie holes, shall be repaired immediately after form removal. All fins shall be completely removed. All honeycombed and other defective concrete shall be removed down to sound concrete. If chipping is necessary, the edges shall be perpendicular to the surface or slightly undercut. No feather edges shall be permitted.

The area to be repaired shall be given a coating of bonding grout or approved bonding adhesive prior to placing the patching mixture.

The patching mixtures shall be made of the same materials and of approximately the same proportions as used for the concrete, except that the coarse aggregate shall be omitted and the mortar shall consist of not more than one part cement to two-and-a-half (2-1/2) parts sand by damp loose volume.

The patching mixture used in repair work shall be cured in accordance with the procedures described above under Curing.

All patched areas shall match the adjacent concrete surfaces.

7.4 TESTING

Contractor shall employ an independent testing laboratory to perform concrete testing. One set of concrete tests shall be taken each day concrete is placed. An additional set of tests shall be taken for every forty (40) cubic yards of concrete poured in one day. A set of concrete tests consists of the following paragraphs one through four, although no concrete shall be placed until a slump and air tests are made. If the results are satisfactory the pour and subsequent testing per ASTM procedures may proceed. If the results do not meet these specifications, additional air entrainment additive may be added and the concrete retested for air. Water may be added only if the amount is within the mix design parameters and is not used to refresh concrete that has begun to set.

- Perform at least one slump test per set, per Standard Test Method for Slump of Hydraulic Cement Concrete ASTM C-143.
- Conduct at least one entrained air test per set, per Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method ASTM C-231 or Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method ASTM C-173.
- Prepare four compression test cylinders per set. Test cylinders shall be made, cured, and transported to laboratory per Standard Practice for Making and Curing Concrete Test Specimens in the Field ASTM C-31. Perform compressive strength tests on test cylinders per Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens ASTM C-39 as revised to date. One cylinder shall be broken at 7-days and two broken at 28- days with one cylinder held in reserve.
- Submit test reports for each cylinder tested within three working days to Owner.

Any concrete work that does not meet the specified strength and quality shall be removed and replaced.

7.5 OIL CONTAINMENT SYSTEM INSTALLATION

The Contractor shall supply all labor and materials required to install the transformer oil containment system as shown within the design document package.

The entire oil containment system, including the containment pit and catch basin, the pit liner or membrane if applicable, piping, and oil/water separator vaults shall be water tight. The following tests shall be conducted on the vault, piping and liner system:

- Where applicable, the liner and drain line shall be tested by placing approximately six (6) inches of drain rock into the containment pit to put a partial load on the membrane. The drain line from the pit to the vault shall be plugged at the entrance to the vault and the drain line and pit shall be filled with water. The water level shall be monitored for 24 hours and any leaks in the liner or drain line repaired per Manufacturer's recommendations.

- After any required repairs are made to the vault, liner, or pipe, the test(s) shall be repeated until a successful test has been completed.

8.0 Structural Steel

Contractor shall be responsible for the receipt, inspection and erection of the steel substation structures as detailed on the drawings, and as specified herein. Materials, fabrication, and galvanizing shall be provided by the Contractor's selected fabricator. The Contractor may be required to Furnish miscellaneous brackets or other minor structural components not included within the structural steel package.

8.1 CODES AND STANDARDS

All materials, fabrication, galvanizing and fasteners shall meet the requirements of the most current applicable codes, specifications, and standards, except as otherwise shown or specified herein and as identified in Publications, Certifications and Practices section of these specifications.

8.2 MATERIALS

All material Furnished by Contractor, or the Contractor's selected fabricator, shall be of the designation or grade specified below:

8.2.1 Structural Steel

All steel support and structural members shall be separately ordered, fabricated and galvanized by a qualified fabricator acting as a supplier to the Contractor. The Contractor shall assemble and install the steel support and structural members, supplied by the fabricator, as shown on the detail design package drawings. Unless noted otherwise, the Engineer will provide detailed structural steel fabrication drawings, from which the Contractor's fabricator should be able to perform a material take-off, fabricate, and galvanize the structural steel package. Generally, the structural members are fabricated from HSS tubing 16-inches square and smaller. Requirement drawings are provided by the Engineer for larger structures which are typically fabricated from folded plate material to form a multi-sided tapered column. The Contractor will obtain these larger structures from suppliers with design capability. The Contractor's Supplier will provide design calculations and fabrication detail drawings to the Engineer for verification and acceptance. The Supplier shall provide drawings which are stamped by their responsible engineer holding a current Civil and/or Structural Engineer's license in the project's jurisdiction.

8.2.2 Connecting Bolts

The Contractor shall supply all connecting bolts and nuts required for assembling the support and structural steel. All connecting bolts and nuts shall conform to Designation A-325. All erection bolts and nuts shall be hot-dipped galvanized in accordance with ASTM Designation A-153.

8.3 ASSEMBLY AND ERECTION

Contractor shall provide all supervision, labor, tools, equipment, and transportation necessary to assemble and erect all steel structures on foundations as shown within the design document package and as specified herein.

Structures shall be erected true and plumb with all bolts securely tightened in place. Structures shall be erected by a method that will not overstress structural members or foundations. Adequate time for concrete curing shall be provided before structure erection. Damaged foundations resulting from premature or excessive construction loading shall be repaired or replaced to the complete satisfaction of Owner at Contractor's expense. Should any piece be bent, overstressed or otherwise damaged, it shall be replaced or repaired to the complete satisfaction of Owner at Contractor's expense.

All bolts shall be drawn up so that mating surfaces of connecting members are held tightly together. After all bolts are placed and have been tightened to snug-tight, they shall be tightened additionally by the appropriate nut rotation, as defined in the AISC Specification for Structural Joints using ASTM A-325 or A-490 Bolts. All tools and wrenches shall be of a design that will not damage the steel or galvanizing.

Contractor will be allowed to make only minor changes to the structural steel at the substation site, i.e., reaming of holes, drilling of holes, clipping of angles, and other minor changes as approved by Owner. Bare surfaces resulting from site changes of structural steel shall be painted with ZRC (Zinc Rich Coating) as manufactured by Sealtube Company of Wakefield, Massachusetts. Application of paint shall be in accordance with Manufacturer's recommendations and in accordance with ASTM A-780 Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dipped Galvanized Coatings. Minimum thickness of repaired areas shall comply with American Hot-Dipped Galvanizers Association's Manu-Spec, specifically, organic zinc rich paint – dry film thickness of eight (8) mils, zinc-repair solder – two (2) mils, and sprayed zinc – four (4) mils (minimum of three coats).

Any steel pieces damaged by Contractor shall be repaired or replaced by Contractor.

The Engineer will provide a foundation design which requires the structure's baseplate to be attached to the anchor bolts using jacking and top nuts. Care should be taken by the Contractor to provide a uniform spacing between the top of concrete and the bottom of the baseplate to accommodate tubular bus alignment. The space between the structure baseplates and the top of its associated foundation will not be filled with grout material.

9.0 Shield Wire System

The shield wire system consists of free-standing steel poles (static mast poles) and deadend column extension masts, support hardware on structures, shield wires, and all grounding materials, as shown on drawings.

The Contractor shall install the shield wire system as shown on the Shield Wire Plan Drawing. Contractor shall supply all materials for the shield wire system, including the structural steel masts and poles. The structures are free-standing (without guy wires) galvanized steel rectangular poles. All shield wire pole foundations are the responsibility of the Contractor and shall be installed per the foundation drawings.

Conductors used for overhead shield (ground) wire applications shall be manufactured by AFL Telecommunications under the trade name Alumoweld, an aluminum-clad steel conductor, consisting of seven (7) strands of #8 AWG clad wire. Galvanized guy wire (EHS steel) is not permitted in shield wire installations.

Each end of each span shall be terminated using a bolted strain clamp fitting and a deadend insulator, regardless of whether the end is bonded to ground or not. Deadend insulators shall have a minimum SML rating of 15,000 LBS, and section length equivalent to 150 kV BIL minimum.

At locations where the spans are bonded to ground, the shield wire shall be connected to ground through two (2) parallel paths to the ground grid using 4/0 AWG copper conductors.

10.0 Conduit and Surface Trench

Contractor shall provide all conduit and surface trench. Contractor shall also Furnish all material, labor, tools, and equipment necessary to excavate for and install the conduit system and surface trench in the substation as shown on the drawings and as specified herein. Contractor shall Furnish backfill for the conduit trenches and all PVC cement, cleaning solvent and other miscellaneous items required for installation of the conduit system. Conduit shall bear UL label.

10.1 EXCAVATION AND BACKFILL

10.1.1 Excavation

10.1.1.1 Depth

Conduits are classified as those containing medium-voltage (greater than 2000 Volts) power cables, and those containing low-voltage (2000 Volts or less) station service, control, and protection circuit cables. The following guidelines shall apply to determine the appropriate trench depth for the two conduits classifications.

Since conduits and the ground grid are installed prior to placing the top layer (4-inches) of finish rock material any reference to depth refers to the depth below rough grade. Typically, the deepest trenching is associated with conduits containing medium-voltage power cables (Class CM). The Contractor is advised to install these conduits first at a minimum depth of 32-inches below rough grade. Within the fenced area of the Substation these conduits shall also have a minimum of 6-inches of lean concrete slurry surrounding them on the top and sides running its entire length.

The conduits containing low-voltage cables (Class CL) shall be placed with a minimum of 6-inches separation and above the conduits containing medium-voltage power cables at a depth between 22-inches and 32-inches below rough grade. Class CM and CL conduits are not to be installed in the same trench, and should cross each other with an interior angle of greater than 30 degrees.

In most cases, the ground grid conductor will be trenched in after the conduits have been trenched and placed. The ground conductor is to be installed at a depth of between 14-inches and 20-inches below rough grade. The exception may be in the case of site with a deep frost depth, and native soil with a relatively high electrical resistivity.

Lastly, low-voltage surface cable trench will be installed above all other below grade components. The surface cable trench is generally 16-inches deep to the interior bottom and 19-inches deep to the exterior bottom. To be flush with finish grade the exterior bottom will be installed a nominal depth of 15-inches below rough grade.

10.1.1.2 Trench Bottom

The trench bottom shall be level and relatively smooth undisturbed earth, well-tamped earth or select backfill, and any elevation change shall be gradual so that the conduit is evenly supported along its entire length. Rock spurs or ridges shall not project into the trench.

10.1.1.3 Drainage

When conduits are installed to cable hand-holes (pull boxes), they shall be sloped to drain towards the vaults, if the terrain allows. The minimum slope is 4-inches per 100-feet of conduit.

10.1.1.4 Width

In no case may a trench used for conduit have a width of less than 8-inches.

10.1.2 Backfill Materials

Bedding material for conduits and surface trenches shall consist of clean sand with 100% passing a one 1-inch sieve and not more than 8% passing a No. 200 sieve.

No material shall be placed when either material placed, or material on which it is placed, is frozen.

Fill shall be placed in horizontal layers having a thickness of not more than 6-inches before being compacted. Each lift shall be conditioned to near optimum moisture content and compacted to a dry density equivalent to at least 95 percent of the dry density obtainable by the Modified Proctor ASTM D-1557.

10.2 CONDUIT MATERIAL AND FITTINGS

10.2.1 Permissible Conduit Types

Rigid Galvanized Steel conduit (RGS) shall be hot-dipped galvanized with a chromated protective layer meeting the requirements of ANSI C80.1 and UL6. All 45-degree or 90-degree elbows in underground conduit runs longer than 100-feet or larger than 2-inch inside diameter shall be RGS conduit. Any conduits and conduit bodies running along the top of foundations to control panels, gutters, wireways, or junction boxes shall be rigid steel conduit. Any conduit that may be walked-on, stepped-on, or climbed-on shall be RGS conduit. The minimum size conduit for RGS steel conduit is 1-inch.

Electric Metallic Tubing (EMT) shall be hot-dipped galvanized with chromated and lacquered protective layer. EMT shall not be used outdoors. The minimum size EMT conduit shall be 1/2-inch.

All outdoor conduits exposed to direct sunlight shall be RGS conduit or Flexible Metal Liquid-Tight conduit.

PVC Schedule 40 and Schedule 80 (PVC) conduit shall meet the requirements of NEMA TC2 and UL 651. The conduit shall be UL listed for concrete encasement, underground direct burial, concealed, or direct sunlight exposure, and 90 deg. C insulated conductors. PVC conduit containing medium-voltage power cables shall be Schedule 80. All underground conduits can either be Schedule 40 or Schedule 80. PVC conduit used in low-voltage applications may not extend above finish grade beyond 6-inches. Install a socket-to-female treaded transition coupler at or near finish grade. The minimum size PVC conduit shall be 1-inch.

Flexible Metal Liquid-Tight (FLT) conduit shall be UL 360 listed, similar to Thomas & Betts Type ATLA, rated for service over an ambient temperature range of minus 50 deg. C to plus 105 deg. C. The conduit shall be fabricated with galvanized steel and an extruded PVC jacket. No FLT conduit shall be used where it can be stepped on or crushed. Where feasible, the length of 2-inches and smaller FLT conduit should be limited to 36-inches.

10.2.2 Fittings

10.2.2.1 Rigid Galvanized Steel (RGS) Conduit

- The conduit and couplings must meet the requirements of UL 514B and shall be threaded.
- Bushings: Bushings for RGS conduit shall be threaded galvanized steel with an integral insulating plastic throat rated for 105 deg. C. Approved Suppliers are: Thomas & Betts, Type BIM or OZ Gedney, Type HB.
- Grounding Bushing: Grounding bushings for RGS conduit shall be threaded bushings fabricated with malleable iron and an integral insulating plastic throat rated for 150 deg. C and with solderless lugs. Approved Suppliers are: Appleton, Series GIB or OZ Gedney, Type HBLG.
- Conduit Hub: Conduit hubs for RGS conduit shall be malleable iron hubs with an integral insulating plastic throat. Approved Suppliers are: OZ Gedney, Series CH, or Thomas & Betts, Series 370.
- Conduit Bodies: Conduit bodies for RGS conduit shall be malleable iron conduit bodies, sized as required by NFPA 70. Approved Suppliers are: Appleton, Form 35 threaded Unilets, or Crouse-Hinds, Form 7 or 8 threaded conduits, or Killark, Series O Electrolets.
- Drains and Breathers: Where drains or breathers are required, they shall be 1/2-inch, threaded and have a well inside the inner threaded end to provide for accumulation of sediment without clogging when used as a drain. Approved Suppliers are: Appleton, Crouse-Hinds, Killark, or OZ Gedney.

10.2.2.2 Electric Metallic Tubing

The fittings must meet the requirements of UL 514B. No set-screw connectors or couplings are allowed. Only compression type connectors or couplings shall be installed. Compression rings shall be made of stainless steel.

10.2.2.3 PVC Conduit:

Use PVC, slip-on fittings, meeting the requirements of NEMA TC-3.

10.2.2.4 Flexible Metal Liquid-Tight (FLT) Conduit

Connectors for FLT conduit shall be threaded steel with an integral insulating plastic throat. Connectors shall be supplied with nylon or polyethylene split sealing ring rated for 105 deg. C and steel grounding ferrule. Approved Supplier: T&B, Series 5300 fittings

10.2.3 Wireways, Gutters, and Wiring Troughs

Wireways, gutters, and wiring troughs must meet the requirements of UL 870 and shall be minimum 14- gauge with removable, screw type covers. All wireways, gutters, and troughs shall be either NEMA 3R Raintight or NEMA 4 enclosures. Covers shall have captivated plated steel or stainless steel screws. The finish shall be ANSI 61 gray with a baked polyester powder finish inside and outside. Approved Suppliers: B-Line Systems and Hoffman.

10.2.4 Miscellaneous

10.2.4.1 Duct Bank Spacers

Use non-metallic, interlocking spacers for multiple conduit sizes. Spacers shall be suitable for all types of conduit.

Approved Suppliers: Underground Device, Inc., Type WUNPEECE spacers

10.2.4.2 Conduit Support Hardware

Indoor Installations – For indoor conduit support, Unistrut, or an equivalent strut system manufacturer's product, channels can be mild coated steel, galvanized steel or aluminum. All nuts, bolts, channel nuts, and washers can be electro-galvanized steel. Conduit clamps can be steel or aluminum.

Outdoor Installations – For outdoor conduit support, Unistrut, or an equivalent strut system manufacturer's product, channels shall be aluminum. All nuts, bolts, channel nuts, and washers shall be stainless steel. Conduit clamps shall be aluminum or stainless steel. Where only one conduit is routed along a steel member, galvanized pipe straps shall be used whenever possible.

10.3 CONDUIT INSTALLATION AND CONNECTIONS TO EQUIPMENT

10.3.1 General Installation Requirements

Conduits and conduit banks shall be buried in accordance with the minimum depths defined in the Excavation and Backfill section above. The conduits should be installed below the ground grid conductors where possible. If the ground grid conductors are damaged during the installation of the conduits, the conductors shall be repaired using an exothermic welding process.

All material and equipment shall be stored appropriately to protect it from the deteriorating effects of the elements. Touch-up paint shall be provided as required. Immediately after installation, plug or cap the raceway ends with watertight and dust-tight seals until the time for pulling the conductors. Avoid moisture traps where possible. When moisture is unavoidable in exposed conduit runs, provide a junction box and drain fitting at the conduit low point.

Paint the threads of RGS conduits with zinc-rich paint or liquid galvanizing compound, before the assembly of fittings for RGS conduit that is installed in exposed or damp locations, or directly buried.

All metal conduits must be reamed, with burrs removed, and cleaned before the installation of conductors, wire, or cable.

Do not install raceways in concrete equipment pads or foundations. Conduit, conduit fittings and conduit boxes that will be embedded in concrete shall be held securely in position with non-metallic supports while the concrete is being placed.

PVC conduit containing medium-voltage power cables (applications such as the shunt capacitor bank steps) routed within the fenced area of the Substation shall be covered on top and sides with a minimum of 6-inches of lean concrete slurry.

10.3.2 Conduit Placement

All conduit runs shall comply with the requirements of the NEC. Conduit runs shall be fully assembled at the trench side. After appropriate conduit cement set-time, the conduit run shall be lowered into a properly prepared trench, as close to the trench center as possible.

Every effort shall be made to provide a straight conduit run between bends. Conduit shall not snake horizontally along the trench bottom. Conduit runs shall be as straight as possible before trench backfill is placed.

Circuit routing shall be as shown on the drawings unless conditions are encountered that necessitate a change in the routing. If a field change is required, the Contractor shall promptly notify the Engineer for approval of a change.

After conduits have been installed, they shall be kept clean, free of moisture and ready for cable installation. Crushed, deformed or damaged raceways shall be replaced by the Contractor at Contractor expense.

Conduits shall follow contours of foundations and structures for a neat appearance and shall be firmly fastened on steel structures with pipe straps.

10.3.3 Conduit Terminations

Contractor shall terminate conduits with locknuts on the inside and outside of a cabinet, wireway, gutter, trough, or junction box and bushings or as directed on the drawings. Where equipment is provided with tapped conduit entrances, locknuts are not necessary, but terminations shall be made with bushings unless conduit entrance is provided with a rounded-off boss butting against the end of the conduit.

Avoid entering any junction box, control cabinet, wireway, gutter, or trough from the top or exposed side. Any conduit entry into a junction box, control cabinet, wireway, gutter or trough where the conduit is outdoors and is routed above the enclosure, shall be fitted with a drain at the enclosure entry point.

Where RGS conduit terminates in a threaded hub and a rounded-off boss is not part of the hub, install an insulated throat in the hub to protect the conductors.

Where RGS conduit terminates with locknuts and bushings at cabinets, wireways, troughs, or junction boxes, grounded bushings are required for conduits over two 2-inches inside diameter if power conductors are routed in the conduit. Conduit termination for either RGS or EMT conduit in service panels or enclosures shall be made with grounded bushings regardless of size. For all other applications, plastic sleeved bushings for metal conduits shall be used.

Locknuts used on the outside of cabinets, wireways, gutters, troughs or junction boxes that are exposed to the weather shall be sealing type.

Additional holes, if required to connect to equipment, panels, cabinets, boxes, gutters, or wireways shall be punched in the field. Unused holes shall be closed with a plate fastened in place by screws.

10.3.4 Conduit Support

Support conduit from structural members only, at intervals not exceeding NFPA 70 (NEC) requirements and, in any case, not exceeding 8-feet. Do not support the conduit from piping or other raceways.

For multiple adjacent raceways, provide Unistrut support anchored to structural members. For overhead racks provide a trapeze consisting of 1/2-inch all-thread bolts and Unistrut.

Do not weld raceways or pipe straps to steel structures. Do not use wire in lieu of straps or hangers. Holes in steel members for conduit supports shall be the responsibility of the Contractor. All holes drilled in structural members shall be kept to a minimum. Beam clamps shall be used whenever possible. All drilled holes shall be painted with Zinc Rich Coating (ZRC) prior to installation of hardware.

10.3.5 Bends

A run of conduit, embedded or exposed, shall not contain more than the equivalent of four 90-degree bends (360-degrees total) between pull points, e.g., conduit bodies and boxes. Pull boxes shall be installed, if required to limit any run of conduit to four (4) 90-degree bends.

Make all bends and offsets of the longest practical radius. All conduits larger than 2-inches inside diameter shall have a 24-inch radius.

Use factory made bends whenever possible. Avoid field-made bends and offsets, but where necessary, make field-made bends with a bending machine. Do not bend RGS with a hickey. Do not heat metal raceways to facilitate bending.

Make bends in parallel or banked runs from the same center or centerline with the same radius so that bends are parallel.

Do not make bends in flexible conduit that exceed allowable bending radius of cable to be installed or that significantly restricts conduit flexibility.

10.3.6 Below Station Ground Grid

All underground conduits shall be installed below the station ground grid with a minimum of 1-inch of sand between conduits both vertically and horizontally as shown on the drawings. If not specified on the drawings, low voltage power and control cable raceways shall be buried at a minimum of 24-inches.

10.3.7 Trench

Conduit trench shall be smooth and filled with 3-inches of sand to provide bedding for raceways. The first 3-inches of backfill above the pipe zone shall be sand or soil free of materials that would damage or be corrosive to the conduit.

10.3.8 Minimum Grade

Maintain minimum grade of 3-inches in 100-feet, either from one man-hole, hand-hole, or pull box to the next, or from a high point between them, depending on surface contour.

10.4 SURFACE TRENCH

Contractor shall purchase and install all components of an enclosed surface trench system as described below and as shown on the drawings. Contractor shall install the components per the instructions provided by the supplier of the Surface Trench system manufactured by Trenwa, Inc. Two types of trench systems are required.

10.4.1 Pedestrian Type

Pedestrian Open Bottom Type, which mainly consists of, but is not limited to, precast concrete, U-shaped base surface trench and removable covers (made of fiber and steel reinforced concrete). Trenwa's one piece trench system includes Base Model BP, Lid Model LP and GC3 Ground Cable Clip Surface Trench to be installed in earth trenches with covers extending above the surrounding crushed rock surface. Trenches are constructed of 10-foot sections, except where required based on the layout in the drawings. The surface trench shall support at least 200-pounds per square foot live load for pedestrian traffic or 7000-pounds GVW for pick-up trucks and light duty vehicles. The trench shall have interior clear cross sectional area and dimensions as shown on the drawings.

10.4.2 Road Crossing Type

Surface Trench System, Road Crossing Type, (with solid bottom) which mainly consists of, but is not limited to, precast concrete U-shaped base and removable covers. Trenwa's one piece trench system (Base Model BHC) shall be installed in earth trenches with covers either flush with the road surface or extending above the surrounding crushed rock surface. Trenches are constructed of 10-foot sections, except where required based on layout in the drawings. The trench shall be designed to carry HS20, 32,000-pounds axle loading (minimum). The trench shall have interior clear cross sectional area and dimensions as shown on the drawings.

10.4.3 Trench Grounding

Both types of trench shall be supplied with ground clips. The clips shall be located on both sides of the trench wall and be spaced 5-feet apart. The clips shall be capable of connecting to 2/0 copper conductor.

11.0 Grounding

This section covers requirements for a complete grounding system installation for the substation, as shown on the drawings.

This includes the grounding of all elements of the station including the metallic structures, ground switches, shield wires, lightning arrestors, circuit breakers, meter cabinets, potential and current transformers, fence, control building panels, switch platforms, conduit bushings, cables and other appropriate items.

Grounding shall be established in accordance with the latest edition of IEEE 80, Guide for Safety in Substation Grounding and the National Electrical Code.

Contractor shall provide all material, labor, tools, and equipment necessary to construct the grounding system as shown on the drawings and as specified herein. Materials required for below ground bonding of the ground grid shall be provided by the Contractor.

11.1 ABOVE GROUND INSTALLATION

Above ground connections of ground cables from the ground grid to steel structures, equipment, buildings, and fence shall be securely made with exothermic welded type connectors securely bolted to the structures and equipment. All steel conduits shall be effectively grounded either by direct grounds or by attachment to metal enclosures that are adequately grounded. Holes necessary for attaching grounding connectors to some structural supports may have to be drilled by the Contractor. Ground pads shall be used where available. Ground leads shall be run up and over the footings and up the structures in a neat and workmanlike manner.

In all cases where connections to the ground grid are stubbed out at equipment footings in advance of equipment installation, care shall be taken that sufficient length of the grounding conductor plus a reasonable margin is left, so that it may be trained up along the wall of the footing and made to follow all surfaces closely in routing the grounding conductor to the point of connection. Avoid disturbing galvanized finish of structural steel when routing and terminating structure and equipment grounds.

All equipment and all steel structures shall be connected to the ground system as shown on the drawings. This includes, but is not limited to, all panels, junction boxes, and auxiliary equipment. Even though metallic junction boxes and yard aluminum boxes are mechanically fastened to the steel or aluminum yard structures, a bonding conductor shall be installed to provide a supplemental electrical ground. Boxes 12-inch x 12-inch x 6-inch and smaller need not have a bonding ground conductor if there are no receptacles mounted in them.

Paint, rust, or other no-conducting materials shall be completely removed from the contact surfaces and these surfaces coated with oxide inhibiting compound (NO-OX-ID) before making ground connections. Holes drilled in the structures to fasten ground cables shall be re-galvanized as noted on the Drawing. All unpainted or nongalvanized metal surfaces remaining after the ground connection has been made shall be restored to its original finish.

The Contractor shall neatly train conductors to equipment along the face of the footing or structural steel, following all surfaces closely to point of connection. Conductors running to equipment shall be supported and secured with cable fasteners at intervals no greater than 5-feet.

Unless negotiated otherwise with the acceptance of the Owner and Engineer, all grounding conductors, with the exception of the fence and perimeter grounds, are to be soft-drawn, stranded copper, #2, #2/0, or #4/0 AWG as indicated in the Grounding Details (E-231). Alternate conductors, if accepted, are to be 40% copper clad steel, with an equivalent fusing current.

11.1.1 Metallic Structures

Ground conductors shall be bolted to structures by means of a 2-hole terminal connector, similar to Cadweld Type LA or DMC Power Type GC920-T, tin plated lug using stainless steel bolts with stainless steel spring lock and flat washers. NO-OX-ID grease shall be used to coat the lug surface mating with structure ground pad or aluminum grounding surface on equipment. Fence and gate grounding shall be as shown on the drawings.

11.1.2 Equipment

Circuit breakers, switches, instrument transformers, etc. shall be grounded through their ground pads with 2-hole terminal connector, similar to Cadweld Type LA, tin plated lugs. Each major equipment item shall be attached to the main ground grid at a minimum of two locations from opposite sides or corners of the equipment as shown in the drawings.

11.1.3 Handhole Grounding

Install one ground rod inside each handhole.

The ground rod floor protrusion shall be 4-inches to 6-inches above the floor.

Install a #2 AWG bare copper grounding conductor along the perimeter of the interior of the vault installed approximately 6-inches below multi-tap frames and cable supports.

Connect all noncurrent-carrying metal parts and any metallic raceway grounding bushings to the #2 AWG grounding conductor with the appropriately sized bonding jumper.

Make connections of grounding conductors fully visible and accessible in surface trench.

11.1.4 Surface Trench Grounding

Install 2/0 AWG stranded bare copper grounding conductor at both sides of the surface trench as shown within the Grounding Details Drawings. Surface trenches containing the medium-voltage power cables originating from within the Collector System may utilize the same grounding cable used in the direct-buried trench. Since a ground (shield) cable is required on both sides of the surface trench, the installer may loop the cable back to the surface trench transition section after bonding to the switchgear vault ground loop.

Connect all noncurrent-carrying metal parts, including metallic surface trench lids, and any metallic raceway grounding bushings to the grounding conductor with #2 AWG bare copper conductors or other appropriately sized bonding jumper.

The surface trench grounding conductors are to be bonded to the Substation (Station) ground grid at intervals of no more than thirty (30) feet, particularly at locations where the trench crosses the grid conductors.

11.1.5 Switchgear Enclosure Ground Loop

Provide a 4/0 AWG copper conductor ground loop within the switchgear vault, with a minimum of two (2) 4/0 AWG copper ground pigtails connected to the Substation ground grid.

Provide single radial 2/0 AWG minimum copper ground conductor for grounding of cable trays, medium-voltage cable terminations, switchgear, and other equipment in the switchgear vault.

The switchgear enclosure shall be grounded at all four corners with 4/0 AWG copper ground pigtails connected to the ground grid. The switchgear Supplier will provide ground pads at the enclosure corners, providing an interface for the Contractor's ground pigtails. The Contractor shall verify that the switchgear Supplier has bonded these pads to a ground bus within the switchgear enclosure.

11.1.6 Lightning Arresters

Station Type Arresters: Provide 4/0 AWG (minimum) bare copper conductor lead from the ground grid to the arrester support structure ground pad. Install 2/0 AWG bare copper conductor up the structure to the arrester ground pad. Use compression type connectors to terminate the 2/0 AWG copper on the arrester ground pad.

11.1.7 Disconnects and Air Break Switch Frames

Install 4/0 bare copper conductors from the station ground grid to the grounding pads on the structures supporting air break disconnect switches

11.1.8 Local Service Transformers

Ground the primary circuit neutral directly to the structure grounding conductor or the substation ground grid conductor. When distribution type transformers are used for AC local service, ground the secondary circuit neutral at the transformer location only.

11.1.9 Substation Fence

The substation fence, including the gates in any position, shall be grounded to the inner perimeter ground conductor buried 3-feet inside the fence as shown on the drawings. At locations where the inner perimeter ground conductor intersects the soft copper grid conductor, a copper-clad jumper shall also be connected to the outer perimeter ground conductor.

The following fence parts shall be bonded to the perimeter ground conductor with copper-clad ground conductor as specified on the drawings.

- Each corner post.
- Every fifth line post.
- Each gate post and gate.

The fence fabric top rail and strands of barbed wire at the top shall be grounded. The copper-clad pigtail ground conductor shall be connected to the post with a U-bolt connector, continued up the post, and terminated at the top rail with a U-bolt connector. A #6 soft-drawn copper conductor (tie wire) shall be connected to the pigtail of the 7/#6 DSA copperweld ground conductor at the top rail U-bolt connector and routed to each barbed wire strand. Attach the ground to each of the barbed wire strands with split bolt connectors.

Gates are to be grounded to each gatepost with a 3/4-inch copper braid and Burndy Type GAR or equal fittings on the gate frame.

All external fences shall be isolated from the substation fence and main ground grid.

11.1.10 Miscellaneous

Bond system neutrals, service equipment enclosures, exposed noncurrent-carrying metal parts of electrical equipment, metal raceways, ground conductor in raceways and cables, receptacle ground connections, and metal piping systems in conformance with the National Electrical Code.

Extend and connect ground conductors from the ground mat to the ground bus in all equipment containing a ground bus. Bond the enclosure of equipment containing a ground bus to the bus. Grounding conductor sizes shall be as shown on the drawings as required by the National Electrical Code.

11.2 BELOW GROUND INSTALLATION

The main ground grid or mat shall consist of a minimum of 4/0 bare, soft drawn, stranded copper conductor as per the Grounding Plan (E-230) and Grounding Details (E-231). All ground rods shall be 3/4-inch diameter, 10-foot long copperweld rods. The grid or mat configuration is shown in the Grounding Plan (E-230).

The perimeter ground conductors, located parallel to the station perimeter fence both 3-feet inside and outside the fence line shall be copper-clad material. The copper-clad perimeter ground conductors, including the cross jumpers, shall be 40% 19-strands of #9 AWG clad wire. The copper-clad pigtail conductors used to bond to fence posts shall be 40% 7-strands of #6 AWG clad wire. The soft aluminum ground conductors used to bond the fence fabric and wire shall be solid soft 1350 aluminum alloy #6 AWG tie wire.

The ground grid shall be buried below top of yard finish rock approximately 30-inches deep unless otherwise shown on the drawings. The ground grid conductors shall be bonded at points

of crossover, connections to ground rods, and at all tap points. Bonding shall be accomplished by using either an exothermic welding process such as Cadweld® or by brazing with SIL-FOS. Compression type ground fittings are not permitted for the below ground installation.

The grounding system consists of trenching for laying the ground grid, including all taps, installing the ground grid, ground rods, ground mats, taps and ground connections to the fence. The grounding system also includes connections to equipment, junction boxes, and structures as shown on the drawings. All taps at ground rods shall be connected with separate connectors to the main ground grid. Below grade grounding connections shall be exothermic welded type as specified herein. All dirt shall be removed from the splice area, and care shall be taken to ensure the conductors are clean and dry just prior to making the connection. Each connection shall be inspected and approved before the trench may be backfilled.

Ground rods shall be driven full length or to refusal. If refusal is less than 8-feet, then a drilled 4-inch diameter hole is required for the rod as described below. At refusal the rod shall be cut and connected as if the rod were driven full length. The Owner shall be informed immediately of all rods that were not driven to full length. The location of ground rods will be as shown on the drawings. Connect ground rods to the main ground grid using a Cadweld Type GT mold.

Where a solid or stratified rock is encountered, the Contractor shall auger a single hole 10-1/2-feet deep and at least 4-inches in diameter. Ground rods shall be placed in the hole and supported at the center. Pour a premixed slurry of one-and-a-half to two gallons of clean water to one, twenty-four pound bag of Ground Enhancement Material (GEM) around the rod. Approximately three (3) twenty-four pound bags will be required for each rod. Fill the 4-inch diameter hole up to 6-inches from the top of the rod. The GEM slurry shall be thoroughly tamped full depth to eliminated voids and ensure proper fill around rod.

Grounding mats shall be installed where personnel stand to operate switching devices such as air break switches, ground switches, hook operated disconnect and fused switches, and bus disconnect switches. The location of ground mats will be shown on the drawings. Ground mats are installed 6-inches below finished grade. See the grounding drawings for details.

Excavated materials removed during trenching, that are free of clay lumps, deleterious materials, or stones larger than 1-inch in greatest dimension, may be used for backfill of ground trenches. Fill material shall be free of rocks or clods larger than 1-inch, vegetation, pieces of wood or other organic material larger than 1/2-inch in diameter. No backfill is to be placed when either material placed, or material on which it is placed, is frozen. Fill shall be deposited in layers, leaving a maximum thickness of 6-inches before being compacted. Compaction shall be done with mechanical tampers to at least 95% of modified proctor ASTM D-1557. After installing the below grade ground conductors and the final inspection is completed, the trench shall be backfilled with excavated material or other low resistivity backfill material. Do not backfill with sand, gravel, or crushed rock.

Interconnect reinforcing bars in concrete foundation to anchor bolts and other metallic structures to be cast in the concrete utilizing #4 soft drawn black iron wire. Weld wires to the anchor bolts and connect to the rebar with hose clamps. Connection to the main ground grid will be through the equipment to be mounted on the concrete foundations.

12.0 Bus and Connectors

12.1 TUBULAR AND WIRE BUS

Contractor shall provide all tubular and wire bus. Contractor shall also provide all labor, tools, and equipment necessary to install the tubular and wire bus, as shown on the drawings.

12.1.1 Tubular Bus

Contractor shall cut the tubing in the field to the exact lengths required. Tubing shall be cut off square and all burrs removed. Any deformation of the cut edge of the tubing shall be filed off.

Horizontal tubular bus spans shall be installed with a slight upward deflection that will tend to neutralize the deflection (sag) due to the weight of the bus and taps. Finished bus spans shall deflect no more than 1/150th of the span, upon installation.

Weeping hole has to be drilled in bottom of horizontal or vertical bus or any fittings to prevent water accumulation. Weeping hole diameter shall be 3/16-inch and to be hi-lighted in black.

Field bends shall be made approximately to the radius shown on the drawings and the curvature shall be continuous and uniform with a minimum of flattening or crimping.

12.1.2 Wire Bus

Jumpers and vertical cable taps shall be installed of such length and form as to maintain maximum clearance from surrounding objects and to give assurance that such contour will be stable.

12.1.3 Damaged Material

The tubular and wire bus shall be handled in such a manner that no surface damage will occur. The outer surfaces of all installed conductors shall remain smooth and free from scratches, nicks, dents or other surface damage.

All damaged material shall be repaired or replaced. Damage shall include all surface defects which can be felt by the fingers and shall include all visible defects. Minor damage to tubular bus may be repaired by filing and smoothing with fine emery cloth to restore the surface so no damage can be felt. Severely damaged tubular bus shall be repaired by cutting out the damaged section and installing a coupling.

All damaged wire bus shall be repaired or replaced. Any damage which reduces the area of any strand to one-half its original area or less shall be repaired by the installation of Contractor Furnished preformed armor rods. Severe damage shall be repaired by cutting out the damaged section and installing a Contractor Furnished compression splice.

All wire bus cut out and replaced because of damage, and all splices and preformed patch rods installed because of damage to conductor shall be the responsibility of Contractor. All conductor, preformed rods and splices shall be Furnished by Contractor.

12.2 BUS CONNECTIONS

Contractor shall provide all bus fittings and connectors and all material, labor, tools, and equipment necessary to install bus fittings and connectors, as specified herein and as shown on the drawings.

12.2.1 Aluminum Tubular Bus

Welded fittings shall be used for aluminum tubular bus. Fittings and bus assemblies, such as A-frames, shall be welded using the inert gas tungsten arc method or metallic arc inert gas shielding method. All welding shall be smooth and done in a good workmanlike manner. If any welds are rough, they shall be ground and polished smooth so as to be corona-free.

12.2.1.1 Aluminum and Copper Wire

Copper/Bronze Bolted Terminals: All copper wire connectors 2/0 AWG and larger shall be bolted fittings or compression when a 2-hole NEMA pad is specified as the interface. Contact surfaces shall be cleaned down to the bright metal with emery cloth and then covered with corrosion inhibiting compound. The surfaces shall be wire brushed so as to groove the compound on the surface and shall be bolted or clamped in place without removing the compound.

Aluminum Compression Fittings: All aluminum wire connectors shall be welded or compression fittings. Contractor shall follow fitting Manufacturer recommendations for installation.

12.2.2 Damaged Fittings

Fittings shall be handled in such a manner that no surface damage will occur. The outer surfaces of all installed fittings shall remain smooth and free from scratches, nicks, dents or other surface damage.

Damaged material shall be repaired or replaced. Damage shall include all surface defects that can be felt by the fingers and shall include all visible defects. Minor damage to fittings may be repaired by filing and smoothing with fine emery cloth to restore the surface so no damage can be felt. Severely damaged fittings shall be replaced.

12.3 VIBRATION DAMPING

The Contractor shall supply and install vibration damping conductors in all horizontal aluminum tubular bus spans that exceed the values listed below.

12.3.1 Minimum Bus Span Lengths

Listed below are the minimum aluminum tubular bus span lengths and damping wire size requirements:

2-inch IPS	12-foot Span	2/0 AAC or ACSR
3-inch IPS	15-foot Span	397.5 kcmil AAC or ACSR
3-inch EHPS	15-foot Span	397.5 kcmil AAC or ACSR
4-inch IPS	18-foot Span	954.0 kcmil AAC or ACSR
5-inch IPS	21-foot Span	954 kcmil AAC or ACSR

The damping conductor shall be neither straightened nor kinked before inserting into the tubular bus. Both ends of the horizontal bus shall be closed after the damping conductor has been installed.

13.0 Medium-Voltage Cable (15 kV)

This section covers the requirements for the materials, installation, termination, testing, and labeling of the 15 kV medium-voltage power cable between the switch and bus, conduit risers, and the 15 kV capacitor bank steps. It does not include any of the distribution circuit cables or other 15 kV cables that enter the Substation from outside locations and/or are supplied, installed and terminated by others. If the Contractor has access to reel end cable lengths of the cable used in the distribution system this same cable is suitable for applications within the Substation.

13.1 MATERIALS

When included in the Contractor's scope, the Contractor shall supply all 15 kV cable, terminators, and labels. The 15 kV cable shall be installed in conduit as shown on the drawings. Termination kits shall be supplied and installed by the Contractor. Only high-voltage certified personnel shall install termination kits.

13.2 TESTING

All 15 kV cables are to be tested, after installation and terminations are complete, by the Contractor, using an Owner approved PD testing method and subcontractor. DC Hi-pot or VLF testing is not permitted. Re-testing of failed and repaired terminations will be the responsibility of the Contractor.

13.3 MINIMUM SIZES

Medium-voltage cables used within the Substation for the feeder circuit primary power circuit shall be the same size as the cable used in the distribution system. Medium-voltage cables used within the Substation for the single-step shunt capacitor banks shall be at least 350 kcmil aluminum conductor.

14.0 Low-Voltage Power and Control and Instrument Wiring

This section covers the requirements for the materials, installation, splicing, termination, testing and labeling of all power and control wiring rated at 2000 Volts, or less. This includes wiring for station service, AC and DC equipment power systems, station lighting, protective relaying, alarms, metering, SCADA and communication systems. The work shall include the procurement and supplying and placement of cable in cable tray, conduits, gutters, wireways, and surface trenches. It also includes splicing where necessary, terminating the conductors at each end, cable shield termination, labeling, cable tying and bundling.

14.1 MATERIALS

14.1.1 600 Volt Station Service Power Conductors

Acceptable Manufacturers: Anixter, Belden, BrandRex, General Cable, and Okonite.

14.1.1.1 Application

Low-voltage station service power conductors are used to interconnect the incoming service to the control enclosure primary power disconnect switch and the emergency generator to the back-up power disconnect switch. Also, station service power conductors are used to connect control panels and miscellaneous equipment that are both inside and outside the control enclosure to the AC and DC power distribution panels. Outdoor lighting and receptacle power and switching circuits are also power conductors.

The lighting and receptacle power circuit's integral to the control enclosure are by others and are not included in this specification. These conductors are not to be used to connect outdoor equipment to the AC or DC panels.

14.1.1.2 Single Conductors

All power conductors shall be rated at 600 Volts minimum, and shall be stranded copper. Single conductors larger than #10 AWG shall be Class B stranded per ASTM B8. Single conductor insulation type shall be UL Type SIS/XHHW-2; VW-1 rated, and conforms to the applicable requirements of NEMA WC3, WC5, and WC7. Single conductors shall be used only in continuous conduit runs. Recommend General Cable Specification 5150, or equivalent.

14.1.1.3 Cable Assemblies

All conductors used for AC or DC station service power installed in other than continuous conduit runs shall be in a multi-conductor non-shielded cable assembly. Multi-conductor cables shall be constructed in accordance with UL 1277, Type TC-ER, using fillers, as required, with a cable binder tape overall. Conductors in a multi-conductor cable assembly shall be rated at 600V minimum, shall be tin-coated copper, and shall be Class B stranded per ASTM B8. Conductor insulation type shall be flame-retardant cross-linked polyethylene (XLPE) and rated per UL WV-1 at 90 deg. C for wet or dry locations. The cable assembly shall be rated as Tray Cable Type TC. The outer jacket shall be flame-retardant, moisture- and sunlight-resistant polyvinyl chloride (PVC), free stripping and shall comply with the Flame Test requirements as specified in UL 1581. Individual conductors shall be color coded per ICEA/NEMA Method 1, Table E-2, or Method 4. The bare ground conductor, if present, shall only be bonded to ground at the equipment end. Recommend General Cable Specification 4500 and 4550, or equivalent.

14.1.1.4 Typical Cable Sizes

Typical cable assemblies for DC circuits shall be 4C #10, except where otherwise specified in the drawings. Typical assemblies for AC lighting, receptacle or equipment power circuits shall be 4C#12, 4C#10 or 4C#8, 4C#6 depending on loading conditions. For cables used with multiple switched lighting circuits and/or switched lighting circuits with receptacles, other conductor counts may be used such as 7C#12. No lighting or receptacle conductor shall be small than #12 AWG. Where applicable, conductors for receptacles used for an SF6 gas conditioning cart will be 4C#8.

14.1.1.5 Color Coding

Power conductors shall meet the requirements of the National Electrical Code (NEC). Phase conductors shall be black or red; neutral conductors shall be white; and grounding conductors shall be bare or green. If required, colored tape shall be used if the appropriate colors are not available, and if allowed by the NEC.

14.1.2 Indoor Control Conductors

Acceptable Suppliers: Anixter, Belden, BrandRex, General Cable, and Okonite.

14.1.2.1 Application

Indoor control conductors are used for interconnect wiring between the relay panels and other miscellaneous control devices. Only a small amount if any of indoor control wiring should be required by the Contractor. All relay and control panels in the switchgear enclosure shall be supplied and prewired by others. Control conductors that are an integral part of the relay and control panels are by others and not covered in this specification.

14.1.2.2 Cable Assemblies

All conductors used for indoor control applications installed in cable trays, wireways, and vaults shall be in a multi-conductor cable assembly. All indoor control conductors shall be rated at 600 Volts, tin-coated copper, and shall be Class B stranded per ASTM B8. Multi-conductor cables shall be constructed in accordance with UL 1277, Type TC-ER, using fillers, as required, with a cable binder tape overall. Conductor insulation type shall be Flame-Retardant cross-linked polyethylene (XLPE) and rated per UL WV-1 at 90 deg. C for wet or dry locations. The cable assembly shall be rated as Tray Cable Type TC. The outer jacket shall be flame-retardant, moisture- and sunlight-resistant polyvinyl chloride (PVC), free stripping and shall comply with the Flame Test requirements as specified in UL 1581. The bare ground conductor, if included, shall only be bonded to ground at one end. Recommend General Cable Specification 4500, or equivalent.

14.1.2.3 Typical Cable Sizes

Typical cable assemblies shall be 4C#14, 4C#12, 4C#10, 7C#14, 7C#12, 12C#14, and 12C#12. Reference the cable schedule for specific cable sizes.

14.1.2.4 Color Coding

Individual conductors shall be color coded per ICEA/NEMA Method 1, Table E-2. Specific colors for particular applications are listed in this section.

14.1.3 Outdoor Low-Voltage Control Power and Control Conductors

Acceptable Suppliers: General Cable and Okonite

14.1.3.1 Application

Outdoor low voltage control power and control conductors are used to connect outdoor equipment and instruments to the relay and control panels in the switchgear enclosure. DC control power used expressly as part of the control scheme will also be carried within these cable packages. All outdoor low-voltage power and control conductors terminating at the switchgear enclosure will terminate at the Field Terminal Cabinet (FTC).

14.1.3.2 Cable Assemblies

All outdoor low-voltage control power and control conductors shall be rated at 600 volts minimum, tin-coated copper, and shall be Class B stranded per ASTM B8. All conductors used for outdoor control applications shall be in a multi-conductor cable assembly. Multi-conductor cables shall be constructed in accordance with UL 1277, Type TC-LS, using fillers, as required, with a cable binder tape overall. Conductor insulation type shall be cross-linked polyethylene (XLPE) and rated per UL XHHW-2 at 90 deg. C for wet or dry locations. The cable assembly shall be rated as Tray Cable Type TC. The cable core shall be shielded with a 5-mil corrugated copper tape shield. The outer jacket shall be flame-retardant, moisture- and sunlight-resistant, low-smoke polyolefin (PE), free stripping and shall comply with the Flame Test requirements as

specified in UL 1581, 70,000 BTU/Hour. The bare ground conductor if included, and the shield shall only be bonded to ground at the equipment end. Recommend Houston Wire Specification HW174, or equivalent.

14.1.3.3 Typical Cable Sizes

Typical assemblies shall be 4C#6, 4C#8, 4C#10, 7C#12, 7C#10 and 12C#12. Reference the cable schedule for specific cable sizes.

14.1.3.4 Color Coding

Individual conductors shall be color coded per ICEA/NEMA Method 1, Table E-2, or Method 4. Specific colors for particular applications are listed in this section.

14.1.4 Fiber Optic Cable

Acceptable Supplier: Corning

14.1.4.1 Application

Single-mode fiber optic cable shall be used for communication between the Control Enclosure to the Operations and Maintenance building. Multimode fiber optic cable shall be used for communication between the Control Enclosure and the transformer and circuit breaker I/O module and the relays. A fiber optic junction box is supplied in the Control Enclosure to facilitate terminating fiber optic cables.

14.1.4.2 Cable Assemblies

All outdoor fiber optic cable shall be 6-, 12-, or 24-fiber cable as shown on the Cable Schedule.

The cable shall feature standard 62.5/125 Multimode or 9/125 Single-mode fibers. The core tube should include 12-strands of fiber as a minimum. It should feature a high bandwidth. It shall be designed for outside plant applications, underground duct, or direct burial.

A black polyethylene jacket shall surround the cable core. The cable components should be coated with Super Absorbent Polymer (SAP) materials impregnated within the core to prohibit the migration of water. Dielectric strength members, such as fiberglass and/or aramid yarns shall be applied over the cable core to provide the cables tensile strength. The fiber optic cable shall at least comply with the physical characteristics listed in the table below:

Fiber Optic Type	**Multi-Mode**
Fiber Quantity	6-, 12-, or 24- Fibers
Fiber Diameter	62.5/125 Microns
Maximum Attenuation	3.0 @ 850nm dB/km 1.0 @ 1300nm dB/km
Minimum Bandwidth	160 @ 850nm MHz/km 500 @ 1300nm MHz/km

Fiber Optic Type	**Multi-Mode**
Storage Temperature Range	Minus 40 to plus 75 deg. C
Operating Temperature Range	Minus 40 to plus 75 deg. C
Maximum Tensile Load Installation	600 lbs
Maximum Tensile Load Long Term	200 lbs
Minimum Bending Radius Loaded Installation	11-inches
Minimum Bending Radius Long Term	5.5-inches
Nominal Outside Diameter	0.55-inches
Cable Weight (Typical)	124 lbs/1000-feet

Fiber Optic Type	**Single-Mode**
Fiber Quantity	24- or 48-Fibers
Fiber Diameter	9/125 Microns
Maximum Attenuation	0.4 @ 1300 nm dB/km 0.3 @ 1550 nm dB/km
Minimum Bandwidth	N/A
N/A Storage Temperature Range	Minus 40 to plus 75 deg. C
Operating Temperature Range	Minus 40 to plus 75 deg. C
Maximum Tensile Load Installation	600 lbs / 2700 N
Maximum Tensile Load Long Term	200 lbs
Minimum Bending Radius Loaded Installation	11-inches
Minimum Bending Radius Long Term	5.5-inches
Nominal Outside Diameter	0.55-inches
Cable Weight (Typical)	124 lbs/1000-feet

14.1.4.3 Testing Fiber Optic Cables

All fiber optic cable and terminations shall be tested as outlined below:

- Perform a visual inspection of cable and terminations for physical and/or mechanical damage.
- Test procedures and report formats shall be made before testing begins.
- Testing is done with an Optical Time Domain Reflectometer (OTDR) in both directions of the strands. For Multimode fiber, test both directions at 850 nm and1300 nm. For Single-mode fiber, test both directions at 1310 nm and 1550 nm.
- Fiber terminator's responsibilities are not complete until testing is completed and accepted.
- Testing will be done on each strand using a stabilized light source and a fiber optic power meter.
- Testing will be done on each strand on every fiber run from termination to termination.
- All connectorized strands in all cable segments will be tested for loss upon completion of installation.
- The OTDR signal should be analyzed for excessive termination or cable backscatter by viewing the reflected power/distance graph. A copy of this graph shall be included in the test report.

- Attenuation loss measurement shall be expressed in dB/km. Losses shall be within the following values:

Multimode Fiber	3.0 @ 850nm dB/km	1.0 @ 1300nm dB/km
Single-mode Fiber	0.4 @ 1300nm dB/km	0.3 @ 1550nm dB/km

- Any cable segment corrected or repaired shall be re-tested.
- Clean all connectors after testing has been completed before re-mating.

14.1.5 Conductor Connectors and Terminators

Conductors sized #10 AWG through #14 AWG shall be terminated with a non-insulated electrolytic copper ring-type compression connector. The connector shall comply with the requirements of UL Standard 486A/B and shall be used in a method as acceptable to the National Electrical Code. Recommend Thomas & Betts A, B, and C Series non-insulated ring tongue connectors, or equivalent. Conductors #16 AWG and smaller may be terminated with an appropriately sized ring-type compression connector, terminating ferrule or may terminate on a terminal block specifically designed to terminate a conductor without connector or ferrule. Compression connections shall be made using a calibrated ratcheting type tool that can only be released once the full staking action is completed. Recommend Thomas & Betts Catalog #ERG2005 hand tool, or equivalent. The use of bolt cutter/wire stripper or automotive stake-on style tools is not allowed. Insulated conductors are to be stripped with the appropriate hand tool, particularly one that automatically adjusts to the diameter of the wire and strips insulation without damaging the conductor. Insulated wires are to be stripped to the appropriate length, such that bare conductor does not extend outside the crimping barrel of the ring-type connector.

14.1.5.1 Power Conductor Terminations

All insulated power conductors larger than #10 AWG shall be terminated with tin-plated copper, uninsulated, ring-type compression lugs suitable for use with the specific wire size. All conductors #10 AWG and smaller shall be terminated with a tin-plated copper, insulated, ring-type compression lugs suitable for use with the specific wire size. The lug shall have a long barrel with a chamfered/funneled barrel entry. The barrel shall have internal serrations for better gripping and shall either be a one piece tube or have either fully brazed or overlapping seams. The insulation on insulated lugs shall extend past the end of the barrel to provide additional protection from contact with the bare end of a stripped conductor.

14.1.5.2 Control Conductor Terminations

All control conductors shall be terminated with a tin-plated copper, insulated, ring-type compression lugs suitable for use with the specific wire size. The lug shall have a long barrel with a chamfered/funneled barrel entry. The barrel shall have internal serrations for better gripping and shall either be a one piece tube or have either fully brazed or overlapping seams. The insulation on insulated lugs shall extend past the end of the barrel to provide additional protection from contact with the bare end of a stripped conductor.

14.1.5.3 Fiber Optic Terminations

All multimode fiber optic terminations shall be made with epoxy and polish type ST compatible connectors, unless otherwise specified. All single-mode fiber optic terminations shall be made with epoxy and polish type SC compatible connectors, unless otherwise specified. Any Contractor personnel making fiber optic terminations shall be trained and/or certified for fiber optic work.

14.1.6 Miscellaneous Wiring Accessories and Hardware

14.1.6.1 Insulating Tape

Insulating tape shall be cold and weather resistant, 8.5 mil, vinyl plastic, Scotch Brand 88.

14.1.6.2 Insulating Heat Shrink Sleeves

Insulating heat shrink sleeves shall be thermally stabilized, cross-linked polyolefin. The recovered wall thickness shall be equal to or greater than the original conductor insulation. Approved manufacturer is Thomas & Betts Shrink-KON products.

14.1.6.3 Cable Ties

All individual conductors, not installed in plastic wire ducts, shall be neatly bundled and tied with Thomas & Betts Type TY 5242M, or equivalent. Ties shall be tightened with the proper tightening tools. Ties are to be trimmed with a proper wire tie cutting tool to avoid sharp edges and points. The use of side cutters, lineman's pliers, and other such tools to trim ties is not allowed.

14.1.6.4 Cable Identification Markers

Cable ID markers shall consist of 1-3/4-inch by 1-inch rounded rectangular rigid polyethylene tags with the cable number engraved into the tag. The tags shall be flame retardant and tear resistant, printable on both sides recommend Brady TLS 2200/TLS PC Link tags, or equivalent. Cable number engraving shall be at least 1/4-inch high. A 1/4-inch diameter hole shall be drilled 1/4-inch from the tag edge to facilitate attachment of the tag to the cable with an appropriately sized plastic tie. The engraved cable number shall be centered below the attachment hole.

14.1.6.5 Wire Identification Markers

Each #8 AWG and smaller wire (insulated conductor) within a single or multiple conductor packages shall be marked at both ends using a heat-shrink sleeve type marker. The marker shall be labeled using a pre-printed sleeve, with permanent black characters on a white background. Recommend Brady PermaSleeveTM, or equivalent. Label shall bear the wire number assigned per the circuit schedule. If terminal block numbers have been assigned within the schematics and/or diagrams of connection, the label shall also bear the destination terminal block number and terminal point. Lettering shall be applied with a laser or dot-matrix printer, and shall not be hand-written. Labels are to be applied to the conductors before the wire lug is installed. Individual wires larger than #8 AWG shall be marked in a similar manner as the cables.

14.1.6.6 Pulling Compounds

Pulling compounds shall be non-toxic, non-corrosive, non-combustible, non-flammable, UL listed wax-based lubricant. It shall be suitable for use with conductors and cables made of rubber, neoprene, PVC, polyethylene, thermoset silicone and thermoplastics.

14.2 WIRING METHODS

14.2.1 General

Install conductors as shown and as specified in the Bill of Material and Cable List.

Do not exceed cable manufacturer's recommendation for the maximum pulling tensions and minimum bending radii. When pulling compound is used, use only UL listed compounds compatible with the cable outer jacket and with the raceways involved. The Contractor shall be responsible for providing the proper cable pulling equipment and tension dynamometer. The Contractor shall monitor the conductor pulling eye position and pulling tension and record the maximum pulling tensions required for the installation of all conductors.

The Contractor shall carefully inspect all cable for visible defects. The outside of each cable reel shall be carefully inspected and any protruding nails, fastenings, or other object that might damage the cable shall be removed. A thorough visual inspection for flaws, breaks, or abrasions in the cable sheath shall be made as the cable leaves the reel and the pulling speed shall be slow enough to permit this inspection. Damage to the sheath of the cable shall be sufficient cause for rejecting the cable. Instances of damage shall be promptly brought to the attention of the Owner. Cable damaged in any way during installation shall be replaced by and at the expense of the Contractor.

Cable reels shall be stored and handled in a manner that will prevent physical damage to the cable. Cable reels shall be stored on a hard surface to prevent contact between the cable insulation and the earth or gravel due to sinking of the reel. Prevent impact damage between reels by aligning the reels flange to flange or by using guards across the flanges. During storage, the ends of all cable shall be protected with UL listed end caps. If the cable is outdoors and a substantial time delay is expected before terminating the cable, cover both ends of the cable with tape to eliminate the hazards of dirt, moisture, and inadvertent electrical connection.

Immediately prior to the placement of each cable or cable group, inspect the raceway and ascertain that the installation is complete and free of all materials detrimental to the cable or its placement. No wire or cable shall be installed in a conduit unless it is free of all foreign material. Ream, remove burrs, and clear the interior of installed conduit before pulling wires or cables.

Prior to installation of the conductors, pull a mandrel, approximately 1/4-inch smaller than the raceway inside diameter, through each raceway. If the raceway appears inadequate to accommodate the assigned cable(s), notify the Owner. Work shall be discontinued for questionable routes until the Contractor is advised as to how to proceed. Prior to installation, all cable shall be carefully checked for proper size and length before being pulled into conduits, cable trench, or tray in order to minimize pulling stresses and the need for splices. Cable pulled into the wrong conduit or duct or cut too short to rack, train, and splice as specified herein shall be removed and replaced by and at the expense of the Contractor.

14.2.2 Conductor or Cable Assembly Installation

The conductor or cable assemblies shall not be handled when the temperature is below the minimum installation temperature recommended by the manufacturer. If conductor heating is required prior to installation, the conductor shall be stored in a heated building in accordance with manufacturer's recommendation for at least 24-hours. The conductor shall be installed the same day it is removed from heated storage.

All conductors or cables assigned to a particular duct or conduit shall be grouped and pulled-in simultaneously using cable grips and lubricants as necessary. Lubricants shall be applied liberally and continuously during the pull. Any conductor or cable installed in such a manner that the outside jacket receives cuts or abrasions or otherwise is damaged, shall be removed and replaced at the Contractor's expense. To avoid insulation damage from excessive sidewall pressure at bends, the pulling tension of any conductor shall not exceed the maximum tension recommended by the conductor or cable manufacturer. If any excessive strain develops, the pulling operation shall be stopped at once and the difficulty determined and corrected.

When pulling cables through open trench or cable tray, a person is required to assist at corners to avoid conductor damage. Install wire and cable in cable trays parallel and straight. Bundle, in groups, all wire, and cable of same voltage having a common routing and destination using cable ties at maximum intervals of 3-feet.

- Fasten wires, cables, and bundles to the tray with nylon cable straps at the following maximum intervals:
  - Horizontal Runs: 20-feet
  - Vertical Runs: 5-feet
  - Where conductors must pass from the cable trench/tray to instrument panels, they shall be bundled in the trench/tray so they can pass as one group.

14.2.3 Terminations

14.2.3.1 Control and Instrument Cable

Contractor shall install control and instrument cable as follows:

1. Contractor shall install all control cable using the specified size, type and number of conductors, or such substitute sizes as are authorized. Any deviations shall be approved by Owner before making the change.

2. Contractor shall use care in handling cable to prevent damage by sharp bends or excessive pulling strain or abrasion to the sheath from pulling. Cables shall be pulled in one continuous length from termination to termination.

3. Control cables entering equipment external to the control enclosure, shall have the protective sheath removed to the cable entrance point of the equipment. Black shrink-to-fit tubing shall be applied around the cable where the sheath ends. When applicable, the shield shall be terminated at the originating equipment (circuit breaker, transformer, etc.) end only, using a termination kit. Shield terminations shall be connected to ground within the equipment cabinet or junction box. Both ends of the shields shall not be grounded.

4. Cables shall be routed within the yard equipment cabinets to avoid obstructing operating devices and terminal boards. Cables shall be secured in such a way that the cable weight does not pull on the terminal blocks, and cable bundles shall be fastened by tie wraps approximately every 6-inches.

5. Insulation damage occurring during installation shall be repaired with heat shrink tubing.

6. All conductors except spare conductors shall terminate on terminal blocks. Spare conductors in any given cable shall be coiled, marked, and routed to a location in the cabinet that will not interfere with access to any devices in the cabinet or other conduits entering the cabinet. Any spare, unused conductors shall be left with enough length to reach any terminal in the cabinet.

7. The Contractor shall terminate all control conductors, AC, DC, potential and current circuits for all equipment in the substation. This includes, but is not limited to, 69 kV circuit breaker, CIT's, and CVT's. All cables and individual conductors shall be properly terminated and labeled as shown on the wiring diagrams associated with the equipment.

8. Cables associated with current transformer secondary circuits shall have the cable jacket and shield stripped back approximately 6-feet from the end of the insulated conductors, with a minimum of 4-feet coiled adjacent to the terminal block. Follow this procedure at both the originating equipment and at the field termination cabinet. This procedure will reduce the odds of future splicing if rolling of phases or CT ratio changes becomes necessary.

14.2.4 Conductor Splicing

Splicing of conductors to repair damage or shortages during construction is not allowed. In such instances the conductor will be required to be replaced or re-pulled.

14.2.4.1 Power Cable Splices

Splicing of power cables to repair damage or shortages during construction is not allowed. In such instances the conductor will be required to be replaced or re-pulled.

14.2.4.2 Control and Instrument Conductor Splices

Control conductors shall be spliced only on terminal blocks located in easily accessible cabinets or junction boxes. No in-line splices are allowed.

14.2.4.3 Current Transformer Secondary Conductors

Splicing of current transformer secondary conductors will not be allowed.

14.3 CABLE AND CONDUCTOR IDENTIFICATION

All cables and conductors shall be tagged or labeled per the drawings. The Contractor shall review the wiring diagrams and cable schedules and generate a cable and conductor tagging list. This list shall be submitted to the Owner's Engineer prior to fabricating or printing tags or labels.

Spare cables shall be tagged SPARE. The tag shall also be engraved with the number and size of the conductors in the cable, example 4C #10. The tag shall be affixed near the end of the cable to facilitate easy identification in the future.

14.3.1 Color Codes

Conductor color code shall be as shown below:

Color Coding		
Potential and Current Circuit Conductors		
Colors designate the phase of both potential and current circuits. The designated conductor size for current circuits is #10 AWG minimum, and for dual ratio (tapped) potential transformer secondary circuit's 7/C #12. Colors correspond to ICEA/NEMA Table E-2. Numbers in (#) correspond to ICEA/NEMA Method 4, if used.		
Phase A	Black (1)	
Phase B	Red (2)	
Phase C	Blue (3)	
Neutral	Orange (4)	
Power Conductors		
Colors correspond to ICEA/NEMA Table E-1. Numbers in (#) correspond to ICEA/NEMA Method 4, if used.		
Direct Current - DC	Positive	Black (1)
	Negative	White (2)
Alternating Current AC (Single Phase)	X	Black (1)
	Y	Red (3)
	G	Green (4)
	N	White (2)
Control Circuit Conductors		
Control cable conductors should utilize ICEA/NEMA Table E-2 for conductor identification if at all possible. If cables identified with ICEA/NEMA Table E-1 must be used, NEC rules apply when terminating either green or white conductors. Avoid using the green or white conductors if possible, otherwise used an alternate colored tape to designate color at both ends of the cable.		

Refer to the cable schedule for additional cable requirements.

14.4 CONDUCTOR TESTING

All control and instrument conductors shall be tested prior to labeling and terminating to determine circuit and insulation integrity. Any conductors that do not pass the tests as described herein, shall be replaced by either using a spare conductor in the existing cable or by installing a new cable. Cables where all conductors are used (such as 4-conductor CT cables) shall be replaced if any one of the conductors fails to pass the tests.

14.4.1 Conductor Insulation Test

All control and instrument conductors shall be meggered from conductor to ground or from conductor to shield and between individual conductors with a 500 Volts DC Megger. Cables with shields shall have their shield isolated from ground and tested from shield to ground with a 500 Volts Megger. If more than one conductor in a cable is determined to have damaged insulation, the cable shall be replaced and tested again.

14.4.2 Conductor Continuity Test

Each control and instrument conductors in cable assemblies shall be tested for continuity to determine if conductors are broken or open-circuited inside the cable or along the cable routing. A continuity test for the shields in shielded cable shall also be conducted. After initial continuity of the conductors in any given cable has been confirmed, all conductors shall be retested for proper continuity when being cut, labeled and terminated.

15.0 Equipment and Device Labeling

All major equipment and devices within the substation yard shall be properly labeled. The Contractor shall provide identification nameplates made of laminated three-ply plastic, equal to Lamicoid. Nameplates shall be a minimum of 1/8-inch thick, with yellow outer layers on a black core. Edges shall be chamfered. Nameplates shall be fastened to the equipment by using a minimum of one blank rounded screw on each end.

16.0 Lighting System

16.1 YARD LIGHTING

Contractor shall Furnish and install a complete yard lighting system as shown on the drawings. This includes but is not limited to lighting fixtures, lighting poles, cabling, junction boxes, conduit and fittings, switches, contactors, etc. Yard lightning shall be manually operable with a pushbutton control switch located near the primary access gate, within the fenced area of the Substation. Refer to conduit and cable plan/detail drawings for more details.

16.2 SWITCHGEAR ENCLOSURE LIGHTING

All lighting in the GIS switchgear enclosure is supplied by the Switchgear Supplier as an integral part of the enclosure.

16.3 YARD LIGHTING AND RECEPTACLES

Small Equipment Identification at Switchyard shall be labeled. Lighting fixtures and power receptacles shall be identified similar to the above except use 1-inch by 3-inch nameplate with 1/4-inch high letters. The identifications shall include the panel and circuit from which it is served, including device number as shown on drawings.

17.0 Testing and Commissioning

The Contractor is responsible for continuity testing and functional/operational verification of all field wired devices and circuits between the originating devices and the switchgear/control enclosure FTC (or directly to the relay/control panels when an FTC is not used). Additionally, the Contractor shall verify that the control, alarm, and monitoring functions originating from within the switchgear/control enclosure perform as intended. The Owner may provide personnel to observe the final functional testing to confirm that all equipment, control, relaying and interlocking schemes are operating properly before the substation becomes operational. As test results dictate, the Contractor shall take all remedial actions necessary to correct any problems found during testing prior to declaring the substation is ready for energization. Contractor responsibilities include making any remedies inside the switchgear/control enclosure that are deemed necessary by the Relay Protection Commissioning Contractor, excluding changes within the relay panels.

The Relay Protection Commissioning Contractor (RPC) is responsible for inputting relay settings into the protective relaying devices. The RPC will also perform current and voltage injection testing to verify that the protective relaying device pick-up and drop-out is in accordance with the prescribed settings. These activities will be performed within the relay/control panels, particularly using the test switches installed for this purpose.

Should it be determined that wiring/device changes are required within the relay/control panels, the RPC will be responsible for making these changes. However, should it be determined that the changes required are outside the relay/control panels, particularly outside the test switches, the Contractor will be responsible for making these changes. The Contractor shall provide assistance to the RPC, particularly where access to the originating devices within the substation yard may be necessary.

The Contractor shall supply a complete testing and commissioning plan and schedule to the Owner and the Engineer for review and approval at least 60-days prior to the expected or scheduled start date for testing and commissioning. The Contractor shall confirm that all equipment has been installed and is operational, that all AC and DC circuits are terminated and energized and that all control and interlocking wiring connections and terminations are completed prior to the starting of testing and commissioning. The Contractor shall supply the Owner with an updated schedule for the beginning of the testing and commissioning to allow the Owner to schedule personnel to be on site to observe the testing and commissioning.

17.1 RESPONSIBILITIES

Contractor shall:

1. Perform tests in accordance with the Supplier's procedures and instructions for the equipment listed above, excluding control and protection devices within the prewired relay/control panels

2. Make wiring adjustments within the equipment or secondary terminal cabinets to select the appropriate current transformer ratios (as determined by the RPC)

3. Perform a visual inspection of the substation and verify equipment mechanical operation and electrical contact resistivity.

4. Test all instrumentation circuits and devices to confirm correct ratios, polarities, circuit continuity, and device connection using primary current injection.

5. Perform equipment and system functional tests to verify correct wiring, operation, and control of all devices and equipment.

6. Perform operation of automatic transfer switch and confirm proper transfer and operation.

7. Make a substation ground grid resistance measurement.

8. Perform an infrared scan of all terminations and buswork after substation has been energized and generation is on-line and supplying at least 90% of its rated capacity.

9. Provide documentation that all equipment has been satisfactorily set, tested, and checked prior to declaring that the substation is ready for energizing.

Relay Protection Commissioning Contractor shall:

1. Perform protective relaying coordination studies to determine the appropriate relay settings

2. Set and test electronic numerical relays

3. Verify relay and control logic

4. Verify SCADA functions are operational

17.2 DOCUMENTS AND APPROVALS

As noted above, the Contractor shall supply test report forms, applicable to the inspection, mechanical operation and electrical tests performed on each and all equipment for the recording of all completed test results.

Completed forms shall be signed by the Contractor employee or subcontractor responsible for the testing and shall contain an additional sign-off line for the signature of the Owner's representative.

A complete set of signed test reports shall be submitted to the Owner for review and approval prior to energizing the station.

17.3 TEST EQUIPMENT

The Contractor shall supply all test equipment required to perform the tests as outlined in the testing commissioning procedure to be supplied by the Contractor.

The Contractor supplied testing and commissioning procedure shall list all test equipment to be used and the calibration standards used to calibrate each piece of equipment. Confirmation of calibration of each piece of test equipment shall be supplied with the final set of test reports.

17.4 TEST PROCEDURE

The Contractor shall follow the equipment manufacturer's recommendations and perform tests in accordance with the manufacturer's procedures and instructions of all equipment listed above.

In addition, the Contractor's supplied testing and commissioning procedure shall include the National Electrical Testing Association (NETA) testing procedures and instructions as outlined in the latest version of the Acceptance Testing Specifications for Electric Power Distribution Equipment and Systems for all equipment and systems.

The shelter-isle switchgear internal wiring and control will be factory tested by the manufacturer. However, the Contractor shall retest all circuits field connected to equipment outside of the switchgear enclosure. In addition, a retest shall be made of all closing, tripping, and interlocking circuits and devices once all wiring has been completed to confirm proper operation of all protective devices and circuits prior to energizing the substation.

18.0 Drawings and Other Information

18.1 DRAWINGS

18.1.1 General Requirements

The Contractor will receive three sets of construction drawings and specifications. The Contractor shall be responsible for documenting authorized asbuilt conditions, clearly showing where construction activities differ from the information provided, on one set of drawings. The asbuilt drawings shall be submitted to Owner after acceptable completion of activities covered by this specification. All work will not be considered complete until asbuilt drawings have been received and accepted as accurate. Additional sets of drawings will be Furnished as requested at the cost of reproduction and handling.

18.1.2 Scaling and Dimension

In reading sizes, distances, angle, slope, and other measurements on maps or drawings, the values used shall be those given in dimensions and figures and shall not be obtained by scaling from the maps or drawings. When no value is given or the value given must be modified, dimensions obtained by scaling shall be field verified, staked, and approved by the Owner prior to construction. The Contractor is fully responsible for any dimensions that are obtained by scaling. Any work required to be changed because of scaling is the Contractor's responsibility and at the Contractor's expense.

18.2 MATERIAL SPECIFICATION COMPLIANCE

No substitutions for, or deviations from, the specific requirements of this specification will be permitted, without first obtaining written approval from the Owner. Statements of clarification, exception, or deviation made by the Contractor within the Contractor's proposal are not considered binding without confirmation and acceptance by the Owner. Any such statements within the Contractor's proposal may result in the proposal being deemed as "Nonresponsive". Nonresponsive proposals will not be given further consideration.

19.0 Other Inspection Requirements

19.1 QUALITY ASSURANCE (QA) / QUALITY CONTROL (QC)

Contractor shall furnish a copy of the appropriate quality assurance/quality control procedures relating to this product.

Contractor shall have a quality assurance program that meets requirements of ISO 9000. Documentation demonstrating the manufacturer has met these requirements shall be part of the bid documents.

Compliance and suitability of QA/QC procedures for this product shall be evaluated by means of factory inspection trips, self-evaluations, and other methods as deemed appropriate by the Owner.

19.2 QUALITY SURVEILLANCE

A Quality Surveillance Representative (QSR) may be employed by the Owner to be present during the testing of the equipment as specified herein. If a QSR is employed, the QSR will comply with the Contractor's safety and procedural requirements at all times.

19.3 COOPERATION WITH QSR

The Contractor shall cooperate with the QSR and arrange a reasonable and mutually agreeable schedule for the required inspections and witnessing of tests, consistent with maintaining scheduled progress of the equipment.

19.4 AUTHORITY OF QSR

The QSR will have full authority from the Owner to make whatever decisions are necessary to ensure that the completed equipment complies with all requirements of the Owner's documents, and to ensure that all required inspection and witness activities are carried out.

19.5 DISAGREEMENTS

In the event of significant disagreement between the Contractor and the QSR concerning scheduling of inspection or witness activities, or concerning interpretation of the Owner's procurement documents, the Contractor and the QSR shall promptly and jointly contact the Owner to resolve the matter.

Appendix A Substation Specific Information

A.1 OWNER FURNISHED MATERIALS – 115 kV SWITCHYARD

The Owner has elected to Furnish a selective portion of the materials, and will Furnish the major equipment as listed here in Appendix A. The Contractor will be informed prior to issuance of a contract which items have been purchased directly by the Owner. Contractor shall be responsible for determining and providing sufficient quantities of all other miscellaneous materials necessary to complete construction and provide for a complete installation of the Owner Furnished equipment.

Description	Quantity
Main Power Transformer (MPT), 115-12.47Y/7.20 kV, 12/16/20 MVA @45 deg. C rise, 13.44/17.92/22.4 MVA @55 deg. C rise	One (1)
115 kV High-Voltage Circuit Breaker (HVCB), 123 kV, 1200 A CC, 40 kA IC, 3-pole, group-operated, dead tank design	Two (2)
115 kV Disconnect Switch, center-break vee style, 3-pole, group-operated, with worm gear manual operators, 1200 A CC, 7-foot pole spacing, aluminum live parts, furnished with TR286 station post insulators.	Two (2)
15 kV Sectionalizing Switch, center-break vee style, 3-pole, group-operated, with swing handle manual operators, 110 kV BIL, 1200 A CC, 3-foot pole spacing, aluminum live parts, furnished with TR205 station post insulators.	Three (3)
12.47 kV Breaker Disconnect Switch, vertical-break, single pole, hookstick-operated, 110 kV BIL, 1200 A CC, copper live parts, furnished with TR205 station post insulators.	Twenty-four (24)
12.47 kV Breaker/Transfer Bus Disconnect Switch, in-line tandem vertical-break, single pole, hookstick-operated, 110 kV BIL, 1200 A CC, copper live parts, furnished with TR205 station post insulators.	Twelve (12)
15 kV Medium-Voltage Circuit Breaker (MVCB), 15 kV, 1200 A CC, 25 kA IC, 3-pole, group operated, outdoor free-standing, with C2 capacitive switching rating	Five (5)
Relay/Control Panels, pre-fabricated, with relay and control devices mounted and wired internally within each panel	Four (4)
12.47 kV Reactive Switching Device (RSD)	Two (2)
12.47 kV Capacitor Bank Steps, 3600 kVAr Steps	Two (2)
110 KV BIL 4-pole Grounding Switch (4PGRD)	Two (2)
Station Service Transformer, 7200–120/240 volts, 75 kVA, pole-mounted type, single phase	Two (2)

Appendix B Project Information

The following information is specific to the Merced Irrigation District (MID) Pioneer 115 kV substation project. Completion of 'blank areas' in the tables of this Appendix will be supplied once the information is available and/or necessary.

B.1 FACILITY SUMMARY

B.1.1 Site Location and Direction

Project Name	Pioneer Substation	
State	California	
County	Merced	
Nearest City or Town	Livingston, CA	
Latitude (approximate substation location)		37° 23' 49.17" N
Longitude (approximate substation location)		120° 43' 37.08 @
Driving Directions from Nearest Interstate Highway	Highway 99 to Hammatt Avenue	
Project Site Physical Address	Hammatt Avenue, Livingston, CA 95334	
Specific Codes/Publications for Project Locality (if known)		

B.2 ENVIRONMENTAL AND LOCAL CONDITIONS

Descriptions	**Data**		**Source**
Elevation	141	Feet above mean sea level	Google Earth Pro
Average Annual Temperature	61.2	deg. F	Weatherbase
Average High Temperature	74.37	deg. F	Weatherbase
Extreme High Temperature	112	deg. F	Weatherbase
Average Low Temperature	47.8	deg. F	Weatherbase
Extreme Low Temperature	19	deg. F	Weatherbase
Ambient Temperature Range	Minus 7 deg. C to Plus 44 deg. C		Weatherbase
Average Annual Precipitation	12.5	inches	Weatherbase
Storm Intensity 10-year – 1-hour	0.8	inches	NOAA TP-40
Storm Intensity – 10-year – 24-hour	3.0	inches	NOAA TP-40
Bus Design Snow Load (Ground)	20	pounds per square foot	IBC
Bus Design Ice Load with Concurrent Wind	0	inches radial ice	NESC
Bus Design Wind Speed (Basic)	85	miles per hour	NESC
Isokeraunic Level		thunderstorm days per year	
Seismic Zone	High	IBC Zone	IEEE 693
Ground Acceleration: plus or minus 0.35g (IEEE 693 High Qualification Performance Level)			
NEC Classification, Non-Hazardous (NEMA 3S), NFPA 70			

B.3 PROJECT SCHEDULE WITH CRITICAL MILESTONES – ALL EQUIPMENT

Following is the Milestone Schedule for the Project:

Milestone Schedule Item	Date
[This will be completed once the final information is known.]	

B.4 ORGANIZATION AND MANAGEMENT

B.4.1 Owner Project Personnel

The following staff members have key responsibilities for directing the contracted services for this Project. The project team may include other individuals and support staff as necessary to support the Project.

Owner Name	**Merced Irrigation District**
Street Address:	744 W. 20th Street
Mailing Address (if different)	
City State Zip	Merced, CA 95340
Commercial Issues - Purchasing	
Phone	
Fax	
e-mail	
Project Manager/Title	Juan Sandoval, PE
Phone	209-354-2814
Fax	209-726-7010
e-mail	jsandoval@merced.org
Key Project Staff	
Director of Technical Services	
Director Project Construction	
Transmission Origination	
Engineering Manager	
Project Engineer	

B.5 TECHNICAL APPLICATION QUESTIONS

Technical questions regarding this material specification or notice of any other technical matters which arise during the proposal process or during equipment design, manufacture, or test, shall be directed to the Owner's Engineer.

Owner's Engineering Firm Name:	**Stantec Consulting Services Inc.**
Street Address:	9400 SW Barnes Rd., Suite 200
Mailing Address (if different):	[same]
City State Zip	Portland, OR 97225
Phone:	503-297-1631 / 503-297-5429

Function/Description	**Key Individual/Other Information**
Project Sponsor	Nabil Farah, Senior Principal
e-mail	Nabil.Farah@stantec.com
Project Manager	Kenneth Keating, PE, Project Manager
e-mail	Ken.Keating@stantec.com
Key Project Staff	
Electrical Interconnection and System Modeling	Thomas Wier, PE, P&C Manager-Engineering Studies
Physical Layouts and Estimates	Kenneth Long, PE, T&D Engineering Manager
Controls and Protection	Alex Moldovon, PE, P&C Engineering Manager
Communication System	Bob Weiss, RET
Other Project Staff	
Civil/Structural Engineering	Priyatosh Ray, PE, SE, Manager Civil & Structural
Contract Documentation/Purchase Orders	Karen MacKenzie, Office Administrator
Other Project Participants	

End of Document