Norfolk Southern
Electrical Specifications
November 2017

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*** For electrical conduit & handholes, see Section CO – Conduit.*

PART 1 - GENERAL

1.01 SCOPE

A. In general, contractor shall furnish all labor, supervision, equipment and specified materials necessary to provide and install all items defined by the contract drawings and specifications. The scope of this work described in this section is for the Electrical portions of the work per the contract drawings and specifications.

B. Furnish all new electrical equipment included in but not be limited to the Equipment and Materials List in Section 1.01- D and as detailed on the electrical contract drawings and in this specification. Install and mount all equipment and devices as detailed on the electrical contract drawings and in this specification. Furnish and install all cable trays, conduits, and wire; terminate and test all equipment and circuits as detailed on the electrical contract drawings and in this specification. Perform tests and verify functionality of all circuits as specified on the electrical contract drawings and in the specification. Complete work in a timely and complete fashion to provide a fully functional electrical system.

C. Note that the attached electrical specifications are general specifications and are included as a guideline for the installation of the items listed below. They are not a list of work to be performed, nor all inclusive. Reference appropriate drawings and specifications for further detail.

D. Equipment and Materials List:

1. Electric Service and Main Distribution Equipment
2. Equipment Manufactures Fault Coordination Studies
3. Grounding and Bonding
4. Power Distribution Panelboards
5. Feeders and Branch Circuits
6. Raceways including spares as indicated on contract drawings
7. Manholes and Handholes
8. High voltage cable splice and termination system
9. Conductors, Wire and Cables
10. Pull Boxes and Junction Boxes
11. Nameplates, Labels, and Tags
12. Outlets and Boxes
13. Motor Connections and Controls, Motor Starters
14. Disconnect Switches for All Motors
15. Equipment Power Wiring, Control Wiring and Connections
16. Contactors and Remote Control Switches and Relays
17. Lighting Panels, Fixtures and Control
18. Equipment Mounting and Supports

19. Guarantee

20. Required Spare Parts

E. Above list is given as a minimum guide to identify the major parts of the Work. The Contractor is responsible for the takeoffs and quantities as shown on the Contract Drawings and to report to the Owner's representative any errors, omission or inconsistencies prior to execution of the work.

F. It is the intent of the Specifications and Contract Drawings that the electrical project be a complete and finished work, tested and ready for operation. Any apparatus, appliance, material or work not shown on Contract Drawings, but mentioned in the Specifications or vice versa, or any incidental accessories necessary to make the work complete in all respects and ready for operation, shall be furnished, delivered and installed by the Contractor without additional expense to Norfolk Southern.

G. This Section includes general administrative and procedural requirements for electrical installations. The following administrative and procedural requirements are included in this Section:

1. Site Mobilization and Demobilization
2. Submittals
3. Coordination drawings
4. Inspection
5. Record documents
6. Operation and maintenance manuals
7. Delivery, storage, and handling
8. Manufacturer's technical representative
9. Rough-ins
10. Electrical installations
11. Preparation for operation
12. Tests Acceptance Tests
13. Demonstration of complete electrical systems
14. Structural supports
15. Temporary power
16. Cutting and patching
17. Guarantee

H. Contractor shall furnish and install all hangers, supports, straps, boxes, fittings, and other necessary appurtenances not indicated on the drawings but which are required for a complete and properly installed system.

I. Restore site to original conditions, including the removal and disposition of all scrap, debris, and

unused equipment approved for removal by owner's representative. Package any equipment to be returned to OWNER in suitable materials and supply all equipment and labor to relocate said equipment to any location on site as specified by the owner's representative.

J. Contractor shall provide Temporary Facilities as appropriate to facilitate the completion of the Work and in compliance with General Specification 01015.

K. Mobilization shall include: Preparation and issuance of mobilization plan, movement of construction equipment and materials, temporary construction utilities, transportation equipment and establishment of temporary facilities including site offices, etc.

L. Demobilization shall include: Removal of temporary facilities from site, disposal of surplus material, restoration of the site and temporary facilities to their original condition, removal of all construction equipment from site, etc.

1.02 Electrical Work Provided by Others:

A. The Contractor is to arrange and coordinate work with the Local Electrical Utility. The contractor is responsible for the installation as indicated on the plans.

1.03 RELATED SPECIFICATIONS

A. Not Applicable

1.04 CODES AND STANDARDS

A. All Work shall conform to these Specifications and to the applicable requirements of the latest edition of the following codes, regulations and standards.

1. ANSI - American National Standards Institute
2. ASTM - American Society for Testing and Materials
3. IEEE - Institute of Electrical and Electronic Engineers
4. NEC - Latest Edition of National Electric Code
5. NEMA - National Electrical Manufacturers Association
6. OSHA - Occupational Safety and Health Administration.
7. IES - Illuminating Engineering Society of North America.
8. ICEA - Insulated Cable Engineers Association.
9. UL - Underwriters' Laboratories, Inc.
10. Requirements of the applicable Utility companies.
11. Any law, regulation, or decision of the government agency or Authority Having Jurisdiction (AHJ) over this work shall apply.

1.05 SUBMITTALS

A. Drawings and data to be submitted by the Contractor for all Work and equipment are specified herein and under the respective items of equipment and materials to be furnished and shall be

provided in accordance with these Specifications.

B. Complete shop drawings and technical data shall be submitted for review for all equipment. As a minimum, shop drawings shall include bills of materials, front views, assembly drawings, elementary diagrams, connection diagrams, and complete list of spare parts. Overall dimensions and minimum clearance dimensions shall also be shown for all equipment. Diagrams for control equipment shall be in accordance with ANSI Standards.

C. Shop drawings shall be submitted for, but not limited to, the following:

1. Pull boxes larger than 12 inches
2. Terminal cabinets and boxes
3. Panelboards
4. Disconnect switches, and associated enclosures
5. Cables and terminations for 600 volt cables
6. Cables and terminations for 15 kV cables
7. Raceway and supports
8. High voltage cable splice and termination system
9. Transformers and switches
10. Motor Control Center
11. Switchgear

D. Provide coordination graphs and a family of current characteristic curves for all types and sizes of protective relays, circuit breakers and fuses.

E. Each drawing shall be marked with user name, purchaser name, location of facilities, contract number, purchase order number, and item number.

F. Vendor data sheets shall be marked to indicate the item, model, capacities and other characteristics listed in the table or on printed sheets. Vendor Datasheets shall be submitted for, but not limited to, the following:

1. Boxes and enclosures
2. Grounding connectors
3. Lighting fixtures including ballasts, Lighting Panels and Controls
4. Molded case circuit breakers
5. Pushbuttons
6. Manholes and handholes
7. Relays, control and indicating devices
8. Safety switches
9. Control switches
10. Terminal blocks

11. Conduit and fittings
12. Thermostats
13. Lighting controls
14. Pad-mounted transformers and switches
15. Medium voltage cable
16. Medium voltage cable splice and connection system including termination enclosures, load break elbows, and termination kits.

G. Submit an itemized list of spare parts, as recommended by the manufacturers for all electrical equipment to be supplied under this Contract. The list shall include current unit prices and sources of supply.

H. Test procedures and reports requiring submittals as specified in this Division.

I. Operation and maintenance instruction manuals as specified in this Division.

1.06 COORDINATION DRAWINGS

A. Coordinate with all trades as necessary to facilitate timely completion, avoid the necessity for cutting and patching and to ensure proper operation of all equipment.

B. The location of equipment shown on the drawings is approximate (+/- 10'), and the owner's representative reserves the right to relocate any equipment before it is installed without additional cost. Refer to owner's representative and to mechanical and structural drawings issued for construction for final equipment locations.

C. Contractor is to determine the exact location of conduit and electrical equipment based on structural and mechanical equipment locations. This does not mean that the design of the system may be changed. It refers only to the exact location of conduit and equipment with respect to the facility as constructed. Locations of structural systems and mechanical systems take precedence over locations of conduit runs where conflicts occur.

D. Where electrical equipment and/or conduit relocation is necessary, submit other than minor adjustments to owner's representative for approval before proceeding with work.

E. Furnish to appropriate trades, drawings and instructions necessary for construction of concrete bases, concrete encasement and other construction required to accommodate installations under this Division.

F. Obtain all wiring diagrams and other instructions required for proper electrical connection of equipment installed or furnished under other Divisions hereof.

1.07 RECORD DOCUMENTS:

A. Upon completion of the work, contractor shall furnish to the owner's representative one (1) complete set of "Red-Lined" contract drawings which are marked up to show the actual field installation and revised "as built". The contractor shall also provide one (1) complete set of prints marked up and revised "as built" for each of the following: all detail shop drawings, bills of

materials, conduit and cable installation, and all equipment installations. Contractor shall be held responsible for accuracy of all as-built drawings, and will be required to perform additional verification and correction of said drawings after project completion if said drawings are not accurate. Trips and other expenses incurred to verify and correct as-built drawings will be performed solely at the contractor's expense.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Unload and store all owner-furnished equipment. Contractor is responsible to inspect all equipment for damage and report any problems to owner's representative.

B. Contractor shall be responsible to suitably protect equipment in his care from damage until work is accepted by owner. Contractor shall follow manufacturer's recommended procedures for storing said equipment including, but not limited to, storage temperature and protection from weather.

C. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

1.09 OPERATION AND MAINTENANCE MANUALS

A. Furnish to the Engineer 10 bound and indexed copies of an approved operations and instruction manual for the following:

1. Panelboards
2. Lighting control panels
3. Transformers and switches
4. Generators
5. Transfer Switches
6. Switchgear
7. Medium voltage cable connection system including termination enclosures and termination kits

B. The books shall provide comprehensive detailed information on the approved installation, operation and use, troubleshooting, parts list, lubrication and periodic maintenance, together with the source of replacement parts and service for the items of equipment and the systems covered.

C. Where items of equipment and/or systems work in conjunction with one another the interconnections shall be shown on a single sheet, folded out if necessary. A schematic wiring diagram and a description of operation shall be included.

D. Where separate items of equipment specified herein are combined into a single sealed self-contained unit, the drawings and required data shall treat each item of equipment in such self-contained unit as separate items. Referring to such self-contained unit as one item of equipment will not be acceptable.

E. The Operation and Maintenance Manual shall be submitted for approval.

PART 2 - PRODUCTS

2.01 Not Used.

PART 3 - EXECUTION

3.01 ROUGH-INS

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Refer to equipment Specifications in Division 16 for rough-in requirements.

3.02 ELECTRICAL INSTALLATIONS

A. In general, the Project Contract and Bid Sheet take precedence over the Project Plans and Specifications, and the Project Plans take precedence over the Specifications. Unless otherwise directed by the Engineer, the Contractor shall abide by the most restrictive requirement.

B. General: Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment.

C. All electrical installations shall be completed in accordance with the applicable standards of ANSI, IEEE, NEC, NEMA, OSHA, and all applicable federal state, and local codes. Place the equipment accurately in position, level the equipment, properly assemble all equipment which requires assembling, including bus and incoming wires, and adjust and make ready for service the electrical equipment and material required by these Specifications or shown on the Contract Drawings. After the installation is complete, clean each piece of equipment to the satisfaction of the Engineer. All work shall be done in an orderly and workmanlike manner and shall present a neat appearance when completed.

D. Provide excavation and backfilling as necessary for burial of ground cables, duct banks and conduits as shown on the Contract Drawings. Install all underground concrete duct bank and ground grid prior to the placement of concrete floor slab.

E. Embed conduits, ground cables and anchoring devices as specified and shown on the Contract Drawings and coordinate this work with subcontractors and the Engineer so as not to interfere with or delay their work.

F. Dissimilar metals as used herein shall be those which are incompatible in the presence of moisture, as determined from their position in the electrochemical series or from test data. Where dissimilar metals come in contact, paint the joint both inside and out with approved paint so as to exclude moisture from the joint, or provide a suitable barrier separating the metals.

G. Transitions in conduit from one metal to a dissimilar metal shall only be made at boxes or other enclosures except where otherwise specified herein or shown on the Contract Drawings.

H. Furnish the services of installation supervisors as required or specified herein, without cost to the Engineer. The presence of the installation supervisor shall in no way relieve responsibility for the complete and proper installation of the equipment.

I. All equipment installed by the Contractor shall be in accordance with the approved shop drawings and the manufacturer's recommendations and shall operate to the satisfaction of the Engineer. Correct by repair or replacement, damage to or failure of any part of any of the items of the equipment which, in the opinion of the Engineer, has been caused by faulty mechanical or electrical assembly. Perform necessary tests to demonstrate that the electrical and mechanical operation of the equipment is satisfactory and meets the requirements of these Specifications at no additional cost to the Engineer.

J. The Engineer reserves the right to require minor changes in location of equipment without incurring additional costs.

K. Preserve technical data, instructions and manuals furnished with electrical equipment. This material shall be neatly organized, bound and incorporated in the operation and maintenance manuals.

L. All equipment shall be received and inspected immediately upon delivery.

M. Equipment, regardless of whether it is to be installed immediately or stored for some time before installation, shall be kept in a clean dry place. Heaters installed in equipment to prevent formation of moisture shall be energized. Blocks and wires used to hold moving parts in position during shipping and handling shall remain in place until the equipment has been completely installed. All motor rotors shall be turned in accordance with the Manufacturer's instructions. The equipment shall be moved by means of lifting eyes, jacking pads, or other means provided by the manufacturer for that purpose.

N. Equipment shall be installed and assembled in accordance with the Contract Drawings and instructions furnished by the manufacturer. It shall be protected at all times during construction, including furnishing and installing tarpaulins during painting.

3.03 SEALING AND FIRESTOPPING:

A. Sealing and firestopping of sleeves/openings between conduits, cable trays, wireways, troughs, cable-bus, bus duct, etc. and the structural or partition opening shall be the responsibility of the contractor whose work penetrates the opening. The contractor responsible shall hire individuals skilled in such work to do the sealing and firestopping. These individuals hired shall normally and routinely be employed in the sealing and fireproofing occupation.

B. Use a product that has a rating not less than the rating of the wall or floor being penetrated. Reference architectural drawings for identification of fire and/or smoke rated walls and floors.

C. Contractor shall use firestop putty, caulk sealant, intumescent wrapstrips, intumescent firestop collars, firestop mortar or a combination of these products to provide a UL listed system for each application required for this project. Provide mineral wool backing where specified in Manufacturer's application detail.

D. The Contractor shall clean up and remove from the premises, on a daily basis, all debris and rubbish resulting from its work and shall repair all damage to new and existing equipment resulting from its work. When job is complete, this Contractor shall remove all tools, excess material and equipment, etc., from the site.

E. If any conflicts are found in the Design Documents or between the Design Documents and the Specifications, the Contractor shall notify the Engineer of Record, before proceeding.

3.04 PREPARATION FOR OPERATION

A. Electrical equipment shall be properly installed, adjusted, connected and tested by the Contractor before such equipment will be taken over by the Engineer for operational service, unless the Contractor is specifically relieved from performing part of the Work in writing by the Engineer. All circuits shall be checked for proper insulation resistance by a multi-voltage megohmmeter, and for continuity, grounds, and tightness of connections. All shipping block of instruments and mechanisms shall be removed. All equipment shall be thoroughly cleaned inside and outside of all dirt, grease, grit, cable and conductor strippings, metal filings, or any other foreign matter. All items shall be properly cleaned and finish painted, or touch-up painted, as required by the Engineer.

B. Identification markers and nameplates shall be properly and accurately installed by the Contractor.

3.05 TESTS

A. General:

1. Make all required tests to establish that the equipment has been properly installed in accordance with the Contract requirements. Upon completing the installation of each item, carefully inspect and check the equipment for correct and complete assembly of all parts and components in accordance with the manufacturer's drawings and instruction manuals and as directed by the Engineer.

2. Furnish all electrical test equipment and all meters, instruments and miscellaneous equipment and perform all work required or as directed by the Engineer to complete all tests specified herein. In addition to tests specified elsewhere, perform ground system resistance tests, insulation resistance (megohmmeter) tests on all power and control cables, motors, lighting systems, and miscellaneous electrical equipment. Also, complete all equipment checks, lubrication checks, and all artificial loading of starters and circuit breakers. Furnish the Engineer six copies of all test data taken for tests performed by the Contractor which shall be properly signed by an authorized Contractor's representative. The test data forms used for tabulating the information required shall be furnished by the Contractor and shall be acceptable to the Engineer. Submit test records to the Engineer no later than five working days after successful completion of the test.

B. Final Field Tests:

1. Each acceptance test shall be witnessed by the Engineer of Record, unless the Contractor is otherwise advised.

2. All tests shall be scheduled by the Contractor with the Engineer's approval and no testing shall be performed without his approval.

3. The testing shall be performed by and under the immediate supervision of the Contractor.

4. Manufacturers shall be notified of the tests by the Contractor and shall be permitted to

witness high voltage or other tests performed on their equipment if they so request.

C. Low Voltage Wiring and Equipment:

1. Insulation tests shall be applied at each light and appliance panelboard and each distribution panel or switchboard rated 600 volts or less, after wiring is complete but before utilization devices are installed.
2. Tests shall be made using a 1,000 volt DC meghommeter which has been approved by the Engineer.
3. All buses, feeders, and branch circuits shall be tested for insulation and continuity. Each phase shall be insulation-tested to each other phase and to ground.
4. Motors shall be tested phase-to-ground.
5. Insulation resistance reading after 60 seconds of less than two megohms shall be cause for rejection of that device or portion of the system. The suspect item or system element shall be replaced and retested at no additional cost to the Engineer or owner.

D. Controls:

1. Electrical controls, circuits and systems shall be tested by trial operation of control equipment after all wiring is completed to see that each interlock and control function operates in accordance with the Contract Drawings, Specifications, and where indicated, the description of operation for the equipment functioning during testing, the Contractor shall simulate the intended operating condition in the associated control circuits.
2. Locate the cause of any malfunction and make the necessary wiring and/or equipment changes or corrections to obtain the particular system's intended operation. Such changes shall be included in the test report.
3. Control panels shall be operated through all design functions. This shall include remote operation of all equipment and actuation of alarms and indicating devices according to design requirements.
4. Complete operational tests shall be given to all relays and control devices to show that the equipment performs all design functions and meets the Specifications.
5. Annunciator testing shall include the checking of each point by closing the trouble contact and observing the panel operation. Correct functioning of all lamps, alarm cut-off, reset relays, etc., shall be checked.
6. Acceptance Tests by the Contractor
    a. After completion of the tests specified above in paragraphs 1, 2, 3, 4, and 5, perform under the supervision of the Engineer such tests as deemed necessary or advisable to determine that the transformers, power distribution systems, and the control systems are ready for operation.
    b. Remove covers and panels, disconnect and reconnect wiring and provide power to equipment and wiring as required to permit performance of these tests at no additional cost to NS.
    c. Provide two electricians acceptable to the Engineer during acceptance tests. The

Engineer shall schedule the times the electricians have to be available, which may be any time during the day or night and on holidays, as needed.

d. The systems to be tested shall include all Engineer-furnished equipment, Contractor-furnished equipment, and related equipment and systems, control and interlock circuits and devices, protective relays and sensors.

3.06 DEMONSTRATION OF COMPLETE ELECTRICAL SYSTEMS

A. After the electrical systems to be installed by the Contractor have been completed and the various components contained therein have been checked and tested for satisfactory installation and proper operation, the various systems shall be operated a sufficient number of times to demonstrate to the Engineer that all equipment, components, and materials for each such completed system have been properly installed and will perform the desired operation. Such demonstration of all power and control circuitry, lighting system, grounding system and other similar complete systems shall be considered an integral part of the work of the Contract.

B. As determined by the Progress Schedule required to be submitted by the Contractor elsewhere in the Specification, systems may be completed in stages such as to permit testing, adjustments, and subsequent demonstration of proper operation of a completed element of the overall system. In such cases, notify the Engineer, in writing, that such element of the system has been completed and is ready for demonstration for conformity with system requirements, and the Engineer will schedule performance of such demonstration. However, such demonstration of the operability of elements of systems shall not be construed as acceptability of same and will only serve to expedite complete installation of such systems. Acceptance will only be made on satisfactory demonstration of the operability of the system as a whole. If required by the Engineer, such demonstrations shall be performed in the presence of the Manufacturer's installation supervisors for the various components involved in such systems or segments of systems.

C. If, in the opinion of the Engineer, test results show improper adjustment, operation, or performance of any equipment, and such deficiencies are due to negligence or faulty equipment supplied by the Contractor or unsatisfactory installation by the Contractor, the Contractor shall furnish all plant, labor, equipment and materials required to remedy the situation to the satisfaction of the Engineer and at no additional cost to the Engineer.

3.07 Record Reports:

A. During each of the aforementioned tests, maintain a comprehensive set (quantity of duplicates to be determined by the Engineer) of test reports defining the specific condition in which the apparatus is left, after it has been given approval for use in its intended service.

B. Among the specific test requirements, all equipment shall be visually inspected and evaluated on the report as to its general condition both exterior and interior.

C. Unless otherwise directed by the Engineer, the forms used for testing shall be those which are available by the particular equipment manufacturers.

D. A checklist type report for each individual item of major electrical equipment shall include, but not be limited to, the following identification data defining:

1. Equipment name.
2. Item tag number.
3. Manufacturer.
4. Type of class.
5. Application.
6. Installation location.
7. Voltage rating.
8. Date of test.
9. Ambient conditions.
10. Tester's signature.

3.08 STRUCTURAL SUPPORTS

A. All equipment and raceways shall be securely and rigidly supported in accordance with the Contract Drawings and all applicable Specifications.

3.09 TEMPORARY POWER

A. The Electrical Contractor is responsible for providing adequate temporary power during all phases of construction.

3.10 SAFETY REQUIREMENTS

A. Standards: Maintain project in accordance with all applicable safety and insurance standards.

B. Hazards Control:

1. Store volatile wastes in covered metal containers, and remove from premises daily.
2. Prevent accumulation of wastes which create hazardous conditions.
3. Provide adequate ventilation during use of volatile or noxious substances.
4. Conduct cleaning and disposal operations to comply with local ordinances, and anti-pollution laws.
5. Do not burn or bury rubbish and waste materials on job site.
6. Do not dispose of volatile wastes such as mineral spirits, oil, or paint thinner in storm or sanitary drains.
7. Do not dispose of wastes into streams or waterways.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement should be made as per-each type of item.

4.02 PAYMENT

A. The cost of complying with each section of this Specification is included in other bid items.

END OF SECTION

SECTION 16015 – SHORT CIRCUIT COORDINATION STUDY

PART 1 - GENERAL

1.01 SCOPE

A. The Contractor shall furnish short-circuit and protective device coordination studies as prepared by the Equipment Manufacturer.

1.02 RELATED SPECIFICATIONS

A. Not Applicable

1.03 CODES AND STANDARDS

A. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

1. IEEE 141 – Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems
2. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
3. IEEE 399 – Recommended Practice for Industrial and Commercial Power System Analysis
4. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings
5. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems.

B. American National Standards Institute (ANSI):

1. ANSI C57.12.00 – Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
2. ANSI C37.13 – Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures
3. ANSI C37.010 – Standard Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
4. ANSI C 37.41 – Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories.

C. The National Fire Protection Association 70, National Electrical Code, latest edition.

1.04 SUBMITTALS FOR REVIEW/APPROVAL

A. The short-circuit and protective device coordination studies shall be submitted to the Engineer prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment drawings for manufacturing. If formal completion of the studies may cause delay in equipment manufacturing, approval from the Engineer may be obtained for preliminary submittal of sufficient study data to ensure that the selection of device and characteristics will be satisfactory.

1.05 SUBMITTALS FOR CONSTRUCTION

A. The results of the short-circuit and coordination studies shall be summarized in a final report. No more than six (6) bound copies of the complete final report shall be submitted. For large system studies, submittals requiring more than six (6) copies of the report will be provided without the section containing the computer printout of the short-circuit input and output data.

B. The report shall include the following sections:

1. One-line diagram
2. Descriptions, purpose, basis and scope of the study
3. Tabulations of circuit breaker, fuse and other protective device ratings versus calculated short circuit duties
4. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip unit settings, fuse selection
5. Fault current calculations including a definition of terms and guide for interpretation of the computer printout
6. Recommendations for system improvements, where needed
7. Executive Summary.

1.06 QUALIFICATIONS

A. The short-circuit and coordination studies shall be conducted under the supervision and approval of a Registered Professional Electrical Engineer skilled in performing and interpreting the power system studies.

PART 2 - PRODUCTS

2.01 STUDIES

A. Contractor to furnish short-circuit and protective device coordination studies as prefaced by the Equipment Manufacturer.

2.02 DATA COLLECTION

A. Contractor shall furnish all data as required by the power system studies. The Engineer performing the short-circuit and coordination studies shall furnish the Contractor with a listing of required data immediately after award of the contract. The Contractor shall expedite collection of the data to assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to the release of the equipment for manufacturing.

B. Source combination may include present and future motors and generators.

C. Load data utilized may include existing and proposed loads obtained from Contract Drawings provided by Owner, or Contractor.

D. Include fault contribution of existing motors in the study, with motors < 100 hp grouped together. The Contractor shall obtain required existing equipment data, if necessary, to satisfy the study

requirements.

2.03 SHORT-CIRCUIT AND PROTECTIVE DEVICE EVALUATION STUDY

A. Use typical conductor impedances based on IEEE standards 141-1993.

B. Transformer design impedances shall be used when test impedances are not available.

C. Provide the following:

1. Calculation methods and assumptions
2. Selected base per unit quantities
3. One-line diagram of the system being evaluated
4. Source impedance data, including electric utility system and motor fault contribution characteristics
5. Typical calculations
6. Tabulations of calculated quantities
7. Results, conclusions, and recommendations.

D. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each:

1. Electric utility's supply termination point
2. Incoming switchgear
3. Unit substation primary and secondary terminals
4. Low voltage switchgear
5. Motor control centers
6. Standby generators and automatic transfer switches
7. Branch circuit panelboards
8. Other significant locations throughout the system.

E. For grounded systems, provide a bolted line-to-ground fault current study for areas as defined for the three-phase bolted fault short-circuit study.

F. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short circuit ratings
2. Adequacy of switchgear, motor control centers, and panelboard bus bars to withstand short-circuit stresses
3. Adequacy of transformer windings to withstand short-circuit stresses
4. Cable and busway sizes for ability to withstand short-circuit heating
5. Notify Owner in writing, of existing, circuit protective devices improperly rated for the calculated available fault current.

2.04 PROTECTIVE DEVICE COORDINATION STUDY

A. Proposed protective device coordination time-current curves shall be graphically displayed on log-log scale paper.

B. Include on each curve sheet a complete title and one-line diagram with legend identifying the specific portion of the system covered.

C. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.

D. Identify device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.

E. Plot the following characteristics on the curve sheets, where applicable:

1. Electric utility's protective device
2. Medium voltage equipment relays
3. Medium and low voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands
4. Low voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands
5. Transformer full-load current, magnetizing inrush current, and ANSI transformer withstand parameters
6. Conductor damage curves
7. Ground fault protective devices, as applicable
8. Pertinent motor starting characteristics and motor damage points
9. Pertinent generator short-circuit decrement curve and generator damage point
10. Other system load protective devices for the largest branch circuit and the largest feeder circuit breaker in each motor control center.

F. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.

2.05 REPORT SECTIONS

A. Input Data:

1. Short-circuit reactance of rotating machines
2. Cable and conduit materials
3. Bus ducts
4. Transformers
5. Reactors
6. Aerial lines

7. Circuit resistance and reactive values.

B. Short-Circuit Data:
   1. Source fault impedance and generator contributions
   2. X to R ratios
   3. Asymmetry factors
   4. Motor contributions
   5. Short circuit kVA
   6. Symmetrical and asymmetrical fault currents.

C. Recommended Protective Device Settings:
   1. Phase and Ground Relays:
      a. Current transformer ratio
      b. Current setting
      c. Time setting
      d. Instantaneous setting
      e. Specialty non-overcurrent device settings
      f. Recommendations on improved relaying systems, if applicable.
   2. Circuit Breakers:
      a. Adjustable pickups and time delays (long time, short time, ground)
      b. Adjustable time-current characteristic
      c. Adjustable instantaneous pickup
      d. Recommendations on improved trip systems, if applicable.

PART 3 - EXECUTION

3.01 FIELD ADJUSTMENT

A. Adjust relay and protective device settings according to the recommended settings table provided by the coordination study. Field adjustments to be completed by the engineering service division of the Equipment Manufacturer under the Startup and Acceptance Testing contract portion.

B. Make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.

C. Notify Owner in writing of any required major equipment modifications.

D. Following completion of all studies, acceptance testing and startup by the field engineering service division of the Equipment Manufacturer, a 2-year warranty shall be provided on all components manufactured by the engineering service parent manufacturing company.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement should be made as per each short circuit coordination study.

4.02 PAYMENT

A. Payment shall be per each short circuit coordination study.

END OF SECTION

PART 1 - GENERAL

1.01 SCOPE

A. Testing of the equipment and installation is to be included as part of the cost of the items and other work, unless specifically noted otherwise on the Contract Drawings or Bid Documents.

B. Obtain permits and inspections required by laws, ordinances, rules, and regulations and by public authority having jurisdiction; obtain certificates of such inspections and submit same to Owner's Representative. Pay fees, charges, and other expenses in connection therewith.

C. Test all wiring as specified in this Section prior to hookup of electrical equipment to insure that the system is free from short circuits and unintentional grounds. Owner's Representative reserves the right to approve all test results before circuits or equipment are energized for the first time.

D. Test grounding system at origin of each separately derived voltage system and at each piece of distribution equipment (MCC'S, Panelboards, etc.) to insure integrity of grounding system. Conduct this test in accordance with the specifications of this Section.

E. Prior to installation, and again prior to actual start-up, test all new motors, transformers, and distribution equipment as specified in this section. Coordinate Hi-pot and megger tests with all other Contractors as necessary.

F. Verify completeness and electrical function of all Motor Control Circuits, Field Devices, and Instrumentation to Owner Representative's satisfaction. Apply power to circuits and verify that all circuits and devices are functioning properly as shown on the schematics.

G. On completion of electrical work, test operation of equipment and continuity of the conduit system.

H. Submit data taken during such testing to Owner's Representative and pay fees involved in the required testing of equipment.

I. Immediately correct work found unacceptable by Owner's Representative. Work contrary to the plans, specifications, codes, and/or accepted standards of good workmanship is unacceptable.

J. Test all network cabling installations including Ethernet wiring and Fiber Optic cabling. All circuits must be certified to meet Category 5e standards. Conduct this test in accordance with the specifications of this section.

K. Contractor is responsible for verifying control functions, interlocking, and alarms of all hardwired circuits as well as functionality of all installed field devices and instrumentation.

1.02 RELATED SPECIFICATIONS

A. Not Applicable

1.03 CODES AND STANDARDS

A. NEC - National Electrical Code

B. ANSI - American National Standards Institute

C. NEMA - National Electrical Manufacturers Association

D. IEEE - Institute of Electrical and Electronic Engineers

1.04 INSPECTIONS BY OWNER'S REPRESENTATIVE

A. Before any electrical work is covered, Owner's Representative will inspect the work completed up until that time.

B. On completion of electrical work, Owner's Representative will make a final inspection of the work and order any additional tests by Contractor on operation of the equipment, continuity of the conduit system and integrity of the conductors.

1.05 TEST REQUIREMENTS

A. 600 Volt Insulated Wire and Cable

1. Test all cable and leads for continuity and, except for 120/208 volt services, megger test between conductor and ground and between phases with a 1000 volt DC megger. All resistances must be 50 Megohms or greater.
2. Test 120/208 volt services for continuity and identification only.
3. Test all three phase feeders for proper phase sequence. Perform test using phase sequence indicator. Verify that phase sequence has been maintained from point of supply of each separately derived system throughout to all motor control centers, distribution panels, and switchgear.

B. Dry Type Distribution Transformers (480 Volt Primary and below)

1. Megger test primaries after connection to their supply cables are made. Test the primary and the supply cable together back to the open feeder breaker or disconnect.
2. Check continuity and insulation integrity of all windings. For ambient temperatures different than 20 °C, refer to NETA Acceptance Testing Specifications (NETA MTS-2007, or later) standards for proper temperature correction factors.

Transformer Winding Voltage Rating	Megger Test Voltage	Minimum Megger Megohms At Ambient Temperature of 20 °C
480 Volts	1000	500
277 Volts	500	500
208 / 120 Volts	500	500

3. All of the above megger readings shall be "level off" readings as obtained with a motor driven megger.

C. Low Voltage Switchboard Equipment and Breakers

1. Verify that switchboard, breaker and device nameplate information is the same as shown on the one-line diagrams. Report any discrepancies to Owner's Representative.
2. Inspect equipment and each breaker and report damage, loose material, contamination or unfavorable condition of equipment that must be corrected. Clean where appropriate.
3. Check equipment for operation of doors, leveling, security of mounting, operation of latch/locking mechanisms and drawout mechanisms. Correct as required.
4. Visually check that the equipment ground has been properly installed.
5. Inspect the overall bus assembly, control and metering wiring. Test the insulation of each bus phase to phase and phase to ground with a 500 Volt DC megger. Record values and report deficiencies to Owner's Representative.
6. Insert removable breaker elements into positions and check positioning, operation of racking mechanism and interlocks. Operate breakers manually and check main and auxiliary contacts. Clean, dress and adjust contacts where necessary.
7. Operate all relays, interlocks, and trip mechanisms manually to test operation of all circuits. Report all deficiencies to Owner's Representative.
8. Adjust all breaker trips and relay settings based on breaker settings table in Contract Drawings.
9. Test instrumentation and metering for proper operation. Report any deficiencies to Owner's Representative.

D. Medium Voltage Transformers

1. Perform continuity/resistivity checks through all bolted connections and windings using a low-resistance ohmmeter.
2. Make motor driven megger tests to high and low side windings and ground with the other winding grounded. Hold tests for long enough duration to fully charge the windings. For ambient temperatures different than 20°C, refer to NETA Acceptance Testing Specifications (NETA MTS-2007, or later) standards for proper temperature correction factors.

Transformer Winding Voltage Rating	Minimum DC Megger Test Voltage	Minimum Megger Megohms At Ambient Temperature of 20 °C
5001 - 25000 Volts	5000	35,000

3. Prior to placing transformer in regular service, set tap changer to provide rated secondary voltage at no load for the value of primary voltage expected at startup.
4. Visually check secondary neutral point of transformer and verify that transformer's secondary has been connected to grounding electrode with a properly sized conductor.

5. Include the following records in the test report to be submitted to the OWNER for each transformer:
    a. Complete identification of the transformer.
    b. Instrument used to conduct test.
    c. Time, date, and name of individual who conducted the test.
    d. All resistivity/continuity test results.
    e. Megger reading for each winding.
    f. Initial tap changer settings.

E. Medium Voltage Distribution Switchgear

1. Verify that switchgear, breaker and device nameplate information is the same as shown on the one-line diagrams. Verify that fuse sizes and types are in accordance with drawings and specifications. Report any discrepancies to Construction Manager.
2. Inspect equipment and each breaker and report damage, loose material, contamination or unfavorable condition of equipment that must be corrected. Clean where appropriate.
3. Check equipment for operation of doors, leveling, stability of mounting, operation of latch/locking mechanisms and draw-out mechanisms. Test all interlocking systems for proper operation. Correct as required.
4. Visually check that the equipment grounding has been properly installed. Verify integrity of phase barrier materials and installation.
5. Inspect the overall bus assembly, control and metering wiring. Test the insulation of each bus phase to phase and phase to ground with a 1000 Volt DC megger. Record values and report deficiencies to Construction Manager.
6. Switches/Breaker: Perform insulation resistance tests on each pole, phase-to-phase and phase-to-ground with switch or breaker closed and across each open pole for one minute. Test voltage shall be in accordance with manufacturer's published data or Table 100.1 in 2007 NETA Acceptance Testing Specifications (Table 100.1 for switch only). Do not exceed maximum voltage stipulated by manufacturer for breaker test. Report deficiencies to Construction Manager.
7. Switches only: Perform an over-potential test on each pole with switch closed. Test each pole-to-ground with all other poles grounded. Test voltage shall be in accordance with manufacturer's published data or Table 100.2 in 2007 NETA Acceptance Testing Specifications. Report deficiencies to Construction Manager.
8. Switches/Breaker: Measure contact resistance across each switchblade, fuse holder, and vacuum breaker. Measure the resistance of fuses. Record results. Report deficiencies to Construction Manager.
9. Breaker only: Perform minimum pickup voltage tests on trip and close coils. Perform breaker travel and velocity tests. Verify trip, close, trip-free, and anti-pump function.
10. Operate all relays, interlocks, and trip mechanisms manually to test operation of all circuits. Report deficiencies to Construction Manager.

11. Adjust and record all breaker trips and relay settings.

F. Panelboards and Molded-case Breakers

1. Verify that panelboard and breaker nameplate information is the same as shown on the one-line diagram and/or panel schedule and report discrepancies to Owner's Representative.
2. Inspect equipment and each breaker for damage, loose material, contamination or unfavorable condition of equipment. Report to Owner's Representative and correct as necessary.
3. Check equipment for operation of doors, security of mounting, operation of latch/locking mechanisms. Correct any deficiencies.
4. Verify that the equipment ground has been properly installed.
5. Inspect the bus for assembly deficiencies. Test insulation of each bus phase-to-phase and phase-to-ground with a 1000 Volt DC megger. Record values and report any deficiencies to Owner's Representative.
6. Inspect each breaker, operate manually, and electrically where appropriate. Clean, dress contacts, and adjust as necessary.

G. Medium Voltage Cable

1. Inspect exposed sections of cables for physical damage.
2. Perform a shield continuity test on each power cable by ohmmeter method. Shield continuity must not exceed 10 ohms per 1000 feet of cable.
3. Perform a DC high voltage test as specified below:
   a. A DC high potential test after all splices and stress cone terminations are made. Do not include any buss-work.
   b. A complete dielectric absorption test both before and after the high potential test. Use a motor driven megger for these tests and apply until three equal "level off" readings 10 seconds apart are obtained.
   c. In applying the high potential test, test all cables between the conductor and ground with the shield wires connected to their permanent ground. Connect potheads to their permanent ground. Bag or tape exposed conductor on the opposite end of the conductor being tested.
   d. Apply DC high potential test voltage in accordance with IEEE Std. 400-1991: "IEEE Guide for making HIGH-DIRECT-VOLTAGE Tests on Power Cable Systems in the Field". Apply Maximum Test Voltage to cables as specified in the table below:

Voltage Rating	Test Voltage
5KV	25KV
25KV	35KV

e. Hold maximum test voltage for fifteen (15) consecutive minutes. Take leakage readings at thirty (30) second intervals during the first two (2) minutes of the test, and at one (1) minute intervals for the duration of the test. If, after the first minute, the leakage current increases abnormally, stop the test and report the results immediately to the Owner's Representative.

f. Include the following records in the test report to be submitted to the Owner's Representative for each cable:

i Complete identification of the cable.

ii Instruments used to conduct tests.

iii Time, date, and name of individual who conducted the tests.

iv Megger reading versus time data.

v High potential and leakage current versus time data.

vi Shield continuity test results.

H. 480V Motor Control Centers and Combination Starters

1. Verify that the MCC, starter, and breaker nameplate information is the same as shown on the one-line diagrams. Report any discrepancies to Owner's Representative.
2. Inspect the equipment and each starter for damage, loose material, contamination or unfavorable condition of equipment. Clean and correct as necessary.
3. Check equipment for operation of doors, leveling, security of mounting, and operation of latch/locking mechanisms. Correct as required.
4. Verify that the equipment ground has been properly installed.
5. Inspect the overall bus assembly, control and metering wiring. Test the insulation of each bus phase-to-phase and phase-to-ground with a 1000 Volt DC megger. Record values and report deficiencies to Owner's Representative.
6. Check the operation of each disconnect switch, circuit breaker, and door interlock mechanism. Operate breakers manually and check main and auxiliary contacts. Clean, dress and adjust where necessary.
7. Check each contactor and thermal overload relay for proper size and operation. Check operation of auxiliary contacts. Report deficiencies and correct as necessary.
8. Verify sizing of all Feeder Circuit Breakers and Motor Circuit Protectors (MCP) against the one-line diagrams. Adjust all breaker and MCP short-time/instantaneous settings based on Manufacturer's recommendations. Do not exceed maximum settings as set forth in Table 430-152 of the latest NEC.
9. Verify sizing of Control Power Fuses against the one-line diagrams. Test fuses for continuity. Replace blown fuses as needed.

I. Grounding Test

1. Test each ground conductor at the origin of each separately derived voltage system for proper grounding by applying a Ground Tester instrument and using auxiliary ground rods. The resistance reading at any point shall not exceed five (5) ohms.
2. Verify that all connections to the ground grid have been properly made and are in good condition.
3. Verify that equipment grounds show a resistance of one half (0.5) ohms or less to the ground bus or grid.
4. Include the following records in the test report to be submitted to Owner's Representative for each ground point tested:
   a. Complete identification of grounding conductor.
   b. Instrument used to conduct test.
   c. Time, date, and name of individual who conducted the test.
   d. Resistance to ground.

J. Motors (480 Volt, 3-Phase, 1/2 HP and greater)

1. Test all motor windings phase-to-ground with a 1000 Volt DC megger. Insulation resistance should be 50 Megohms or greater. Report any deficiencies to Owner's Representative.
2. Test all three-phase feeders for proper phase sequence. Perform test using phase sequence indicator. Verify proper phase sequence matches Manufacturers requirements. DO NOT "BUMP TEST" MOTORS UNTIL PROPER PHASE SEQUENCE HAS BEEN VERIFIED. Adjust leads as directed by Owner's Representative to provide proper motor rotation.
3. Conduct a "bump test" of each motor in cooperation with Owner's Representative in order to determine proper motor rotation.
4. Include the following records in the test report to be submitted to Owner's Representative for each motor tested:
   a. Complete identification of motor.
   b. Instrument used to conduct test.
   c. Time, date, and name of individual who conducted the test.
   d. Resistance reading for each winding.

K. Motors (4160 Volt, 3-Phase, 250 HP and greater)

1. Test all motor windings phase-to-ground with a 25,000 Volt DC megger. Insulation resistance should be 50 Megohms or greater. Report any deficiencies to Owner's

Representative.

2. Test all three-phase feeders for proper phase sequence. Perform test using phase sequence indicator. Verify proper phase sequence matches Manufacturers requirements. DO NOT "BUMP TEST" MOTORS UNTIL PROPER PHASE SEQUENCE HAS BEEN VERIFIED. Adjust leads as directed by Owner's Representative to provide proper motor rotation.
3. Conduct a "bump test" of each motor in cooperation with Owner's Representative in order to determine proper motor rotation.
4. Include the following records in the test report to be submitted to Owner's Representative for each motor tested:
   a. Complete identification of motor.
   b. Instrument used to conduct test.
   c. Time, date, and name of individual who conducted the test.
   d. Resistance reading for each winding.

L. Actuator and Motor Control Circuits

1. Verify that all actuator and motor control circuits are functioning properly as shown on drawings. At the direction of the Owner's Representative, apply power to circuits and test all pushbuttons, operators, and field devices for proper circuit function.
2. At the direction of the Owner's Representative, for those circuits containing DCS, PLC or other control system outputs, apply power to the circuit and or jumper power at all outputs used to activate circuits at the disengaged output circuits. Verify proper circuit response.
3. At the direction of the Owner's Representative, insure that all Motor Contactors provide feedback to the control system by energizing Motor Auxiliary Contact circuits, energizing the contactor, and verifying feedback voltage at control system input circuits. Verify feedback from the circuit breaker auxiliary contact by switching the circuit breaker on. Also verify feedback from the overload contact while breaker is on.
4. Coordinate test with Owner's Representative for all circuits containing the control system outputs.

M. Field Devices and Local Operator Stations

1. At the direction of the Owner's Representative, verify that all field devices are correctly wired and functioning properly as shown on drawings. Apply power to circuits and test all field devices for proper circuit function.
2. At the direction of the Owner's Representative, the control system input devices are to be powered (if necessary) and actuated, and the proper feedback for both on and off state verified at the system input circuits.

3. At the direction of the Owner's Representative, jump power to all system outputs used to activate field devices, disengage the output card wiring arm, if present. Verify proper control response of the corresponding device from the control system.
4. Coordinate test with Owner's Representative to test field devices containing control system outputs.
5. Calibrate devices as required following manufacturer's instructions. Adjust devices as necessary to ensure device responds properly to equipment and process conditions.

N. Instrumentation

1. At the direction of the Owner's Representative, verify that all instruments are correctly wired and functioning properly as shown on drawings. Apply power to circuits and test all instruments for proper circuit function.
2. At the direction of the Owner's Representative, instruments providing control system feedback are to be powered and activated, and the proper feedback for the process state verified at the control system input circuits. Instrument calibrators, test weights, and similar devices are to be used to simulate process conditions as necessary to ensure appropriate feedback signals are being transmitted to the control system.
3. At the direction of the Owner's Representative, simulate command/demand signals at all system outputs used to activate instruments. Verify proper control response of the corresponding device from the control system.
4. Coordinate test with Owner's Representative to test instruments containing system outputs.

PART 2 - PRODUCTS

2.01 Not Applicable

PART 3 - EXECUTION

3.01 INSTALLATION

A. Perform all tests and submit reports to Owner's Representative as required above. Correct all deficiencies.

B. Contractor is to initial and date each Motor Circuit, control system input and output on the contract drawings as the functionality of that circuit is verified. These initialed drawings are to be submitted to the Owner's Representative upon completion to signify the Contractor has verified and made functional all circuits and devices in the system.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement should be made as per-each type of item.

4.02 PAYMENT

A. The cost of complying with each section of this Specification is included in other bid items.

END OF SECTION

PART 1 - GENERAL

1.01 SCOPE

A. Perform all work in accordance with the latest requirements of the National Electrical Code (NFPA 70) as prepared and published by the National Fire Protection Association.

B. Perform all work in accordance with any applicable state and local codes.

C. All electrical work shall meet the latest and most stringent requirements of the applicable codes and standards in addition to the applicable state and local codes.

1.02 RELATED SPECIFICATIONS

A. Not Applicable

1.03 CODES AND STANDARDS

A. BOCA - Building Officials & Code Administrators

B. NESC - National Electrical Safety Code

C. RUS - Rural Utilities Service

D. OSHA - Occupational Safety and Health Administration

E. NEC - National Electrical Code

F. IEEE - Institute of Electrical and Electronics Engineers

G. NEMA - National Electrical Manufacturer's Association

H. UL - Underwriters Laboratories, Inc.

I. ANSI - American National Standards Institute

J. PCEA - Insulated Power Cable Engineers Association

K. NFPA – National Fire Protection Association

1.04 SUBMITTALS

A. Not Applicable

PART 2 - PRODUCTS

2.01 Not Applicable

PART 3 - EXECUTION

3.01 Not Applicable

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement should be made as per-each type of item.

4.02 PAYMENT

B. The cost of complying with each section of this Specification is included in other bid items.

END OF SECTION

PART 1 - GENERAL

1.01 SCOPE

A. Furnish and install wiring and cables necessary to connect a complete system as called for in the specifications or as noted on the drawings. Install all wiring and cables in conduits unless otherwise noted. Provide all terminations in accordance with manufacturer's recommendations and provide all miscellaneous hardware, accessories, or connectors as required for a completely installed system.

B. Provide all installations in accordance with the latest edition of the National Electrical Code paying particular attention to all rules governing installation in hazardous locations. Install all wiring in process areas, and at boundaries, such that the installation complies with National Electrical Code requirements for the appropriate Class and Division as shown on the Drawings. Provide all seals as required per NEC that are approved for use in such locations.

C. Refer to Owner provided "Electrical Area Classification" drawings for further details. Coordinate with Owner's Representative before installation.

1.02 RELATED SPECIFICATIONS

A. Section 16111 - Conduits and Raceways

B. Section 16020 - Electrical Tests

C. Section 16130 - Electrical Boxes

D. Section 16180 - Equipment Wiring Systems

E. Section 16450 - Grounding and Bonding

1.03 CODES AND STANDARDS

A. NEC - National Electrical Code

B. IEEE - Institute of Electrical and Electronics Engineers

C. NEMA - National Electrical Manufacturer's Association

D. UL - Underwriters Laboratories, Inc.

E. IPCEA - Insulated Power Cable Engineers Association

F. ANSI - American National Standards Institute

1.04 SUBMITTALS

A. Submit to Engineer for approval manufacturer's drawings and data for all communications and Ethernet cable, if applicable.

B. Submit to Engineer for approval manufacturer's drawings and data for all Low Voltage cable.

C. Submit to Engineer for approval manufacturer's drawings and data for all Medium Voltage cable, if applicable.

PART 2 - PRODUCTS

2.01 POWER AND CONTROL CONDUCTORS - 600V AND BELOW

A. Furnish conductors of the AWG size and type shown on the drawings. Where no size and/or type is shown, use conductors not less than #12 for power and lighting and #14 for control. Use copper conductors that have 600 volt Type XHHW, THHN, or THWN insulation. Furnish only stranded copper control conductors that are UL labeled and of American manufacturer. All underground cable to be XHHW.

B. Wire sizes noted on the drawings, but without insulation noted, are based on a maximum of three copper conductors per conduit unless noted otherwise. If more than three conductors are installed in a conduit, de-rate the conductors and increase in size as required by NEC.

C. Furnish equipment grounding conductors #10 AWG and smaller with the same insulation type as the associated circuit conductors and colored green. Equipment grounding conductors No. 8 AWG and larger shall be green or have green tape applied in a continuous wrap where visible at panels and junction boxes, etc.

D. All conductors shall be stranded unless otherwise noted and conform to the latest edition of the Underwriters' Laboratories, Inc., "Standard for Rubber Covered Wires and Cables" and the National Electrical Code.

E. If raceways are changed from those shown on the Drawings, Contractor shall submit calculations for cables supplying loads in new raceway type to ensure NEC requirements are met.

2.02 SINGLE CONDUCTOR POWER CABLE - 25KV

A. Provide 25KV power cable containing Class B compressed concentric stranded copper conductor, extruded conductor shield, cross linked thermosetting polyethylene (XLP) insulation, extruded semi-conducting thermosetting insulation shield, copper shielding tape, and covered with polyvinyl chlorinated jacket for use in aerial, conduit, open tray, and underground duct bank installations, if applicable to this project.

B. Provide cables that can operate continuously at a conductor temperature not in excess of 90°C for normal operation, 130°C for emergency overload conditions, and 250°C for short circuit conditions and are rated at 25 KV, 133% insulation level.

C. Cable shall be UL listed as type MV-90 single conductor cables with 133% insulation level.

2.03 FLEXIBLE MULTI-CONDUCTOR POWER CABLE - 25KV

A. Furnish Type SHD flexible 25KV power cable for connection of the mobile equipment or where power is distributed to structures with limited vertical or horizontal motion, if applicable to this project.

B. Provide multi-conductor cable with a Hypalon outer jacket, 25 KV rated, added reinforcement to the outer jacket for increased tensile strength, inner jacket made of Hypalon material, phase conductors

shielded with semi-conducting cross linked compound ad ethylene-propylene rubber (EPR) insulation, ground conductors, and ground check conductor.

C. Cable shall be UL listed as type SHD and Type MV-90 with 133% insulation level.

2.04 FLEXIBLE MULTI-CONDUCTOR POWER CABLE - 15KV

A. Provide Type MV-90 15KV power cable containing Class B compressed concentric stranded copper conductor, extruded conductor shield, cross linked thermosetting polyethylene (XLP) insulation, extruded semi-conducting thermosetting insulation shield, copper shielding tape, and covered with polyvinyl chlorinated jacket for use in aerial, conduit, open tray, and underground duct bank installations.

B. Provide cables that can operate continuously in wet or dry locations in circuits not exceeding 15000 volts, 133% insulation level, at a conductor temperature not in excess of 90 degree C for normal operation, 130 degree C for emergency overload conditions, and 250 degree C for short circuit conditions.

C. Cable shall be UL listed as type MV-90 single conductor cables with 133% insulation level.

2.05 SHIELDED CONTROL CABLE AND INSTRUMENTATION CABLE

A. Furnish shielded control and instrumentation cable as shown on the Drawings. Furnish cable as called out on the Drawings, in the Specifications, and per manufacturer's recommendations.

B. Furnish # 18 AWG twisted pair cable (non-polarized) for intercom system wiring between master station and remote loudspeaker stations. Pull an extra (spare) for each remote station and install cables in homerun fashion as shown on the contract drawings, if applicable to this project.

C. Furnish all other miscellaneous instrumentation cabling as indicated on the drawings.

D. Submit instrumentation cable data sheets for all instrumentation cabling to Engineer for approval before purchase or installation.

2.06 CCTV CAMERA CABLE

A. Refer to the CCTV Specifications 16800 through 16806 and the Norfolk Southern "NS Copper and Fiber Optic Cabling Standards" for information about cables for the CCTV System.

PART 3 - EXECUTION

3.01 WIRING METHODS

B. Install all power conductors, which include feeders to panels and motor power wiring, continuous and without splices or joints from load side of disconnecting device or overcurrent protective device to load.

C. Install all terminations in hazardous locations per NEC utilizing UL Listed equipment and UL Listed sealing compound for said equipment.

D. Install control conductors which are continuous and without splices or joints from junction box to junction box. Joints in cable will only be permitted in junction boxes approved for the location. Use pressure type mechanical connectors for all joints in wiring. Clean and insulate all wires used in pressure type mechanical connectors. Do not use wire nuts or threaded on connectors for joints.

E. The ampacity of all conductors shall be at least as great as the rating of the fuse or circuit breaker on the line side of the conductors, or in the case of motors, as allowed by code.

1. All conductors for distribution and control equipment terminations shall be based on full 75°C ampacity.
2. All conductors for utilization equipment terminations rated 100 amperes or less shall be based on 60°C ampacity.

F. Categories of wiring installed in separate conduits.

1. Control wiring.
2. Auxiliary systems wiring.
3. All instrumentation and signaling circuits.

G. Furnish cable supports for supporting conductors in vertical raceways per NEC Table 300-19(a) spacing requirements.

H. Coil or bundle and mark all spare wires in terminal boxes. Tape ends of all spare stranded conductors to prevent moisture from entering wire.

I. Run control wiring in separate conduits from lighting and power wiring. Control wiring shall be defined as any wiring except the following:

1. Wiring used exclusively to supply power to motors, heaters, and other similar loads where minimum voltage is 120 VAC.
2. Wiring used to supply power to lighting loads.
3. Wiring used for lightning protection and grounding.
4. Wiring used for feeders to panels.

J. A separate equipment grounding conductor is still required to be run in each control circuit. Except where power and control conductors are run in a common conduit provided that all of the following conditions are met:

1. The power and control conductors must be functionally associated in accordance with NEC Section 725.
2. Power and control conductors must be de-rated in accordance with NEC Section 725 whenever any of the control conductors carry a continuous load.
3. The power conductors must not be larger than Size #1 AWG.
4. Programmable controller input/output wiring between I/O panels and field control devices or control panels must be run in separate conduits from all power and lighting wiring.

K. Run auxiliary, signal, and communications wiring, including analog signal wiring, programmable controller communication wiring, and other low voltage wiring, in separate conduits from other

control, lighting, and power wiring. Separate signal conduits from power conduits by at least one (1) foot for all parallel runs greater than ten (10) feet to prevent noise/interference on signal cables.

L. All conductors of a circuit shall follow the same path through any openings in metal partitions within enclosure.

3.02 WIRE COLOR CODE

A. Furnish color coding for individual AC conductors as follows:

1. Power Conductors

Voltage	A	B	C	Neutral	Ground
240 VAC and below:	Black	Red	Blue	White	Green
250-600 VAC:	Brown	Orange	Yellow	Gray	Green
250-600 VAC:	Black	Red	Blue	N/A	Bare

2. 120 VAC Control Circuits:

a. Hot – Black

b. Control - Red

c. Neutral – White

d. Foreign (to panel) - Yellow

B. For power conductors #10 AWG and smaller, furnish colored insulation. For power conductors No. 8AWG or larger, use 1/2 inch minimum width colored tape, wrapped twice around the conductor at the following points: at each terminal, at each conduit entrance, and at intervals not more than 12 inches apart in all boxes, panels, motor control centers, etc.

C. For individual DC conductors, furnish Blue colored conductors for wiring to terminal blocks and field control devices.

3.03 MARKING

A. All branch circuits shall be marked in the panelboard gutters. Markers shall indicate corresponding branch-circuit numbers.

B. Furnish control wires (with pressure type spade lugs where required on drawings or otherwise in this specification) for termination to terminal blocks and field control devices. Furnish joints in control wires in approved junction boxes using terminal strips. Mark each terminal, as well as each wire entering or leaving the terminal strip, with the appropriate wire number.

C. Mark each conductor, both power and control, with wire numbers at each terminal, junction, control device, motor, starter, etc. using printed wrap-around vinyl type wire markers.

3.04 MEDUIM VOLTAGE POWER CABLE INSTALLATION

A. Prior to installing the cables in the conduit or duct, rod and brush conduit to assure it is free from obstructions.

B. DO NOT EXCEED MAXIMUM RECOMMENDED PULLING FORCE OF CABLE WHEN PULLING IN CONDUIT. Use an approved type of woven cable grip or pulling eye. Apply an approved type of lubricant to the cable before pulling. Insure that the cable bending radii are not less than that recommended by the manufacturer. Seal cable ends during the pulling operation and keep sealed until final joints are made.

C. Terminate cables with stress relief cones as recommended by the manufacturer. Bond shielding tape or copper drain wires to ground at each termination with copper straps.

D. All medium voltage (5kV or 15 kV) cable ends, lugs and connectors connections shall be made using approved kits. Conductor connections and tape wrappings shall be in strict accordance with manufacturer's instructions. The kits shall be appropriate for the connections being made and the type of cable involved. All connections shall be moisture resistant.

E. No splicing of medium voltage (5kV or 15 kV) cables in permanent runs shall be permitted except where specifically called for on the Drawings. For temporary splices or splices specifically called for on the Drawings, modular splicing kits shall be used to allow expansion of splice and ensure waterproof connections.

F. Test cable system by means of High Potential testing and demonstrate satisfactory performance by proof testing after installation per Section 16020.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement shall be made per linear foot by size and type of wire and cable.

B. Linear measurements shall be made between the planimetric start and end points of each cable run. All additional cable lengths, including slack and riser cables, shall be incidental to the cost of installation.

4.02 PAYMENT

A. Payment shall be per linear foot by size and type.

B. Payment shall include furnishing, installing, transporting, labor, incidental materials, testing, etc. for a complete installation.

END OF SECTION

PART 1 - GENERAL

1.01 SCOPE

A. Wall switches, receptacles, occupancy sensors, wall dimmers, device plates and box covers, poke-through service fittings, access floor boxes, photo cells and time clocks.

1.02 RELATED SPECIFICATIONS

Not Applicable

1.03 CODES AND STANDARDS

A. NEC - National Electrical Code

B. IEEE - Institute of Electrical and Electronics Engineers

C. NEMA - National Electrical Manufacturer's Association

D. UL - Underwriters Laboratories, Inc.

E. ANSI - American National Standards Institute

1.04 SUBMITTALS

A. Submit product data under provisions of Section 16010.

B. Provide product data showing model numbers, configurations, finishes, dimensions, and manufacturer's instructions.

C. Manufacturer's Instructions:

1. Indicate application conditions and limitations of use stipulated by product testing agency specified under Regulatory Requirements.

2. Include instructions for storage, handling, protection, examination, preparation, operation and installation of product.

PART 2 - PRODUCTS

2.01 WALL SWITCHES

A. Wall Switches for Lighting Circuits and Motor Loads Under 1/2 HP: Heavy duty use toggle switch, rated 20 amperes and 120/277 volts AC. Switches shall be UL20 Listed and meet Federal Specification WS-896. All switches shall be heavy duty Specification Grade with separate green ground screw.

B. All switches shall be back and side wired, screw clamp type, suitable for solid or stranded wire up to #10 AWG.

C. Handle: White, made of nylon or high impact resistant material.

2.02 RECEPTACLES

A. Convenience and Straight-blade Receptacles: NEMA Type 5-20R, white nylon or high impact resistant face. Receptacles shall be UL498 Listed and meet Federal Specification WC-596. All duplex receptacles shall be heavy duty Specification Grade, 20 amp rated. All receptacles shall be back and side wired, screw clamp type, suitable for solid or stranded wire up to #10 AWG, with a separate green ground screw.

B. Generally, all receptacles shall be duplex convenience type unless otherwise noted.

C. All receptacles installed in outdoor locations, in garages, within 6 feet of the outside edge of sinks, and in other damp or wet locations shall be GFCI type.

D. GFCI Receptacles: Duplex convenience receptacle, Specification Grade, with integral ground fault current interrupter meeting the requirements of UL standard 943 Class A and UL standard 498.

E. Locking-Blade Receptacles: As indicated on drawings.

F. Specific-use Receptacle Configuration: As indicated on drawings.

2.03 OCCUPANCY SENSORS

A. All occupancy sensors shall be hardwired type; battery type shall not be permitted.

B. Wall Mounted (Wall Switch Type)

C. The sensor shall use either passive infrared or, if dual technology, passive infrared and passive acoustic sensing for detecting room occupancy. The unit shall fit in/on a standard single gang switch box and require only two wires and a grounded box for operation.

D. Rated capacity: 600 watts minimum at 120 volts, 60 Hz; 1000 watts minimum at 277 volts, 60 Hz

E. Sensitivity shall be user adjustable or self adjusting type.

F. The delay timer shall be adjusted within a range of 6 to 14 minutes by the contractor in the field. The sensor shall have a test mode for performance testing.

G. The off switch shall have manual override for positive off and automatic on.

H. The test LED shall indicate motion.

I. The area of coverage shall be approximately 180 degrees by 35-40 feet.

J. The unit shall have a five year warranty.

K. Ceiling mounted

1. The sensor shall use either passive infrared or, if dual technology, passive infrared and passive acoustic sensing for detecting room occupancy. The unit shall fit in/on a standard octagon box.
2. Rated capacity shall be 20 amps at 120 or 277 volts, for fluorescent lamps.
3. Sensitivity shall be user adjustable or self adjusting type.
4. The delay timer shall be adjusted within a range of 6 to 14 minutes by the contractor in the field. The sensor shall have a test mode for performance testing.

5. The coverage area shall be 360 degrees by approximately 15 feet radius when mounted at 9 foot height. The sensor shall have provisions, such as masking, to block out problem areas.
6. Test LED to indicate motion.
7. The unit shall have a five year warranty.

2.04 WALL DIMMERS

A. Wall Dimmers: linear slide semiconductor type.

B. Rating: 600 Watts minimum, larger size to accommodate load shown on Contract Drawings.

2.05 2.05 DEVICE PLATES AND BOX COVERS

A. Decorative Cover Plate: White smooth thermoplastic nylon.

B. Weatherproof Cover Plate: Gasketed metal with hinged device covers.

C. Surface Cover Plate: Raised galvanized steel.

2.06 LIGHTING CONTROL PHOTO CELLS

A. The controller shall be rated 1800 watts tungsten at 120, 240 or 277 volts. The cell shall be cadmium sulfide, 1" diameter.

B. The enclosure shall be die cast zinc, gasketed for maximum weather proofing.

C. The enclosure shall include the positioning lug on the top of the enclosure.

D. The unit shall have a delay of up to two minutes to prevent false switching. The ON/Off adjustment shall be done by moving a light selector with a range from 2 to 50 foot-candles.

E. Mounting shall be for a 1/2" conduit nipple.

F. The unit shall have a 5 year warranty.

G. The contacts shall be SPST normally closed.

H. The operational temperature range shall be (-)40 to 140 degrees F(-40 to +60 degrees C).

2.07 TIME CLOCKS

A. Unit shall be a multi-purpose, 7 day, 365 day advance single and skip a day, combination 2-channel electronic time clock with a SPDT switching configuration and astronomic dial.

B. The contacts shall be rated 10 amp resistive at 120/250 VAC, 7.5 amps inductive at 120/250 VAC, 5 amps inductive at 30 VDC and up to 1/2 hp at 250 VAC. The unit shall be rate for 30 VDC, 120 VAC, 250 VAC and 277 VAC.

C. The controller shall be capable of programming in the AM/PM or 24 hour format by jumper selection, in one minute resolution, using 2 buttons only for all basic settings.

D. Display shall be LED type.

E. The unit shall have 365 day and or holiday selection capabilities, with 16 single date and 5 holiday selection options and user selectable daylight savings/standard time functions.

F. The unit shall have 72 hour memory backup with rechargeable battery and charger.

G. The unit shall be capable of manual override, On and OFF to the next scheduled event, using 1 button for each channel.

H. The enclosure shall be rated for indoor or outdoor installation.

2.08 TIME SWITCH

A. The switch shall be programmed to automatically turn lights off after a preset time.

B. The delay timer shall be adjustable with a range of 5 minutes to 12 hours.

C. Switch shall be rated for 120/277V, 1200W load.

D. The switch shall beep a warning every 5 seconds during the last minute of countdown. Also, the switch shall flash lights (for warning) at one minute before timer expires.

E. Time scrolling shall be provided to override preset time by pressing the ON/OFF switch for four seconds.

F. LCD provided to show count down time.

G. The switch shall have zero crossing circuitry.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install wall switches 45 inches above floor, OFF position down.

B. Install wall dimmers 45 inches above floor; de-rate ganged dimmers as instructed by manufacturer; do not use common neutral.

C. Install convenience receptacles 18 inches above floor, 8 inches above counters, grounding pole on top.

D. Install box for telephone jack 18 inches above finished floor. Install box for telephone jack for wall telephone 45 inches above finished floor.

E. Install specific-use receptacles at heights shown on Contract Drawings.

F. Install decorative plates on switch, receptacle, and blank outlets in finished areas.

G. Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas, above accessible ceilings, and on surface-mounted outlets.

H. Install devices and wall plates flush and level.

I. Receptacles shall have a bonding conductor from grounding terminal to the metal conduit system. Self-grounding receptacles using mounting screws as bonding means are not approved.

3.02 FIELD QUALITY CONTROL

A. Inspect each wiring device for defects.

B. Operate each wall switch and sensor with circuit energized and verify proper operation.

C. Verify that each receptacle device is energized.

D. Test each receptacle device for proper polarity.

E. Test each GFCI receptacle device for proper operation.

F. The user agency and EOR or owner personnel reserve the right to be present at all tests.

3.03 OCCUPANCY SENSORS

A. Sensors used in return air plenum ceiling areas shall be installed in an approved enclosure or UL listed for return air plenum.

B. Sensitivity Test: After the sensor has been energized for at least 15 minutes, walk to the middle of the room (if conference room) or sit at the normal desk position (if office). Make no motion for 20 seconds. Move one arm up and down slowly. The test LED should blink.

C. Time Delay Test: Set the time delay for 10 minutes. Walk into the room to activate the sensor then leave room. Sensor must turn lights off at approximately 10 minutes. Walk into the room again to reactivate the lights. Lights should activate within 1 second.

3.04 ADJUSTING

A. Adjust devices and wall plates to be flush and level.

B. Mark all conductors with the panel and circuit number serving the device with a machine generated label, at the device.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement should be made as per-each size and type of item.

4.02 PAYMENT

A. Payment shall be per each size and type.

B. Payment shall include furnishing, installing, transporting, labor, incidental materials, grounding, testing, etc. for a complete installation.

END OF SECTION

PART 1 - GENERAL

1.01 SCOPE

A. Electrical connections to equipment specified under other Divisions and/or Sections or furnished by Owner.

1.02 RELATED SPECIFICATIONS

A. Section 16111 – Conduits and Raceways

B. Section 16120 –Wire and Cable

C. Section 16130 – Electrical Boxes

1.03 CODES AND STANDARDS

A. NEC - National Electrical Code

B. IEEE - Institute of Electrical and Electronics Engineers

C. NEMA - National Electrical Manufacturer's Association

D. UL - Underwriters Laboratories, Inc.

E. ANSI - American National Standards Institute

F. IPCEA - Insulated Power Cable Engineers Association

G. NFPA – National Fire Protection Association

1.04 SUBMITTALS

A. Submit product data under the provisions of Section 16010.

B. Provide data for cord and wiring devices.

1.05 COORDINATION

A. Coordinate all equipment requirements with the various contractors and the Owner. Review the complete set of drawings and specifications to determine the extent of wiring, starters, devices, etc., required.

PART 2 - PRODUCTS

2.01 CORDS AND CAPS

A. Straight-blade Attachment Plug: NEMA WD 1.

B. Locking-blade Attachment Plug: NEMA WD 5.

C. Attachment Plug Configuration: Match receptacle configuration at outlet provided for equipment.

D. Cord Construction: Oil-resistant thermo-set insulated multi-conductor flexible cord with identified equipment grounding conductor, suitable for hard usage in damp locations.

E. Cord Size: Suitable for connected load of equipment and rating of branch circuit overcurrent protection.

2.02 OTHER PRODUCTS

A. Refer to related sections for other product requirements.

PART 3 - EXECUTION

3.01 INSPECTION

A. Verify that equipment is ready for electrical connection, wiring, and energizing.

3.02 PREPARATION

A. Review equipment submittals prior to installation and electrical rough-in. Verify location, size, and type of connections. Coordinate details of equipment connections with supplier and installer.

3.03 INSTALLATION

A. Use wire and cable with insulation suitable for temperatures encountered in heat-producing equipment.

B. Make conduit connections to equipment using flexible conduit. Use liquid-tight flexible conduit in damp or wet locations.

C. Install pre-finished cord set where connection with attachment plug is indicated or specified, or use attachment plug with suitable strain-relief clamps.

D. Provide suitable strain-relief clamps for cord connections to outlet boxes and equipment connection boxes.

E. Make wiring connections in control panel or in wiring compartment of pre-wired equipment in accordance with manufacturer's instructions. Provide interconnecting wiring where indicated.

F. Install disconnect switches, controllers, control stations, and control devices such as limit switches and temperature switches as indicated. Connect with conduit and wiring as indicated.

3.04 EQUIPMENT CONNECTION SCHEDULE

A. As indicated on the Drawings.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement should be made as per-each type of item.

4.02 PAYMENT

A. The cost of complying with each section of this Specification is included in other bid items.

END OF SECTION

PART 1 - GENERAL

1.01 SCOPE

A. Conduit and equipment supports, straps, clamps, steel channel, etc, and fastening hardware for supporting electrical work.

1.02 RELATED SPECIFICATIONS

A. Not Applicable

1.03 CODES AND STANDARDS

A. NEC - National Electrical Code

B. IEEE - Institute of Electrical and Electronics Engineers

C. NEMA - National Electrical Manufacturer's Association

D. UL - Underwriters Laboratories, Inc.

E. ANSI - American National Standards Institute

F. IPCEA - Insulated Power Cable Engineers Association

G. NFPA – National Fire Protection Association

1.04 SUBMITTALS

A. Submit product data under the provisions of Section 16010.

B. Product Data: Provide data for support channel.

1.05 QUALITY ASSURANCE

A. Support systems shall be adequate for weight of equipment and conduit, including wiring, which they carry.

PART 2 - PRODUCTS

2.01 MATERIAL

A. Support Channel: Galvanized.

B. Hardware: Corrosion resistant.

C. Minimum sized threaded rod for supports shall be 3/8".

D. Conduit clamps, straps, supports, etc., shall be steel or malleable iron. One-hole straps shall be heavy duty type. All straps shall have steel or malleable backing plates when conduit is installed on the interior or exterior surface of any exterior building wall.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Fasten hanger rods, conduit clamps, outlet, junction and pull boxes to building structure using pre-cast insert system, preset inserts, beam clamps, expansion anchors, or spring steel clips (interior metal stud walls only).

B. Use toggle bolts or hollow wall fasteners in hollow masonry, plaster, or gypsum board partitions and walls; expansion anchors or preset inserts in solid masonry walls; self-drilling anchors or expansion anchor on concrete surfaces; sheet metal screws in sheet metal studs and wood screws in wood construction.

C. Do not use powder-actuated or plastic anchors.

D. File and de-bur cut ends of support channel and spray paint with cold galvanized paint to prevent rusting.

E. Do not fasten supports to piping, ductwork, mechanical equipment, cable tray or conduit.

F. Do not drill structural steel members unless approved by EOR.

G. Fabricate supports from galvanized structural steel or steel channel, rigidly welded or bolted to present a neat appearance. Use hexagon head bolts with spring lock washers under all nuts.

H. In wet locations, mechanical rooms and electrical rooms install free-standing electrical equipment on 3.5 inch (89 mm) concrete pads.

I. Install surface-mounted cabinets and panelboards with minimum of four anchors. Provide steel channel supports to stand cabinet one inch (25 mm) off wall.

J. Bridge studs top and bottom with channels to support flush-mounted cabinets and panelboards in stud walls.

K. Furnish and install all supports as required to fasten all electrical components required for the project, including free standing supports required for those items remotely mounted from the building structure, catwalks, walkways etc.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement should be made as per-each type of item.

4.02 PAYMENT

A. The cost of complying with each section of this Specification is included in other bid items.

END OF SECTION

PART 1 - GENERAL

1.01 SCOPE

A. This section describes the products and execution requirements relating to labeling of power, lighting, general wiring, signal, fire alarm, and telecommunications wire and cabling. Further, this section includes labeling of all terminations and related sub-systems, including but not limited to nameplates, stenciling, wire and cable marker labeling of all backbone fiber optic (inter-building, tie & riser) cables, terminating equipment and labeling of inner duct (fiber optic).

1.02 RELATED SPECIFICATIONS

A. Section 16120 – Wire and Cable

B. Norfolk Southern – "NS Copper and Fiber Optic Cabling Standards"

1.03 CODES AND STANDARDS

A. NEC - National Electrical Code

B. IEEE - Institute of Electrical and Electronics Engineers

C. NEMA - National Electrical Manufacturer's Association

D. UL - Underwriters Laboratories, Inc.

E. ANSI - American National Standards Institute

F. NFPA – National Fire Protection Association

1.04 SUBMITTALS

A. Submit shop drawings under provisions of Section 16010.

B. Include schedule for nameplates and stenciling.

C. Provide catalog data for markers and labels.

D. Prior to installation, the Contractor shall provide samples of all label types planned for the project. These samples shall include examples of the lettering to be used. Samples shall be mounted on 8 1/2" x 11" sheets annotated, explaining their purposed use.

PART 2 - PRODUCTS

2.01 NAMEPLATES AND LABELS

A. Nameplates: Engraved three-layer laminated plastic, black engraved letters on white phenolic background. Minimum size of 4" x 2 ".

B. Locations: Each electrical distribution and control equipment enclosure.

C. Letter Size:

1. Use 1/8 inch letters for identifying individual equipment and loads.
2. Use 1/4 inch letters for identifying grouped equipment and loads.
3. Use 1/2 inch letters for identifying panelboard.

D. Embossed adhesive tape, with 3/16 inch white letters on black background. Use only for identification of individual control device stations.

2.02 WIRE AND WIRE BUNDLES MARKERS

A. Description: Tape, split sleeve, or tubing type markers.

B. Each conductor or bundle at panelboard gutters, in the raceway (except conduit, duct or tubing raceways) every twenty feet, pull boxes, outlet and junction boxes, and each load connection.

C. Legend:

1. Power and Lighting Circuits: Branch circuit, feeder or base feed number indicated on drawings.
2. Control Circuits: Control wire number indicated on shop drawings.

2.03 CONDUIT MARKERS

A. Description: 1 3/4" x 4" tape.

B. Location: Furnish markers for each conduit longer than 6 feet.

C. Spacing: 20 feet on center.

D. Color:

1. 480 Volt System: Blue
2. 208 Volt System: Black
3. Communication System: Yellow
4. Spare: White

E. Legend:

1. 480 Volt System: 480 V
2. 208 Volt System: 208V
3. Communication System: CM

2.04 MATERIALS

A. Labels: All labels shall be permanent, and machine generated. NO HANDWRITTEN OR NON-PERMANENT LABELS ARE ALLOWED.

B. Label size shall be appropriate for the conductor or cable size(s), as indicated in this section. Flag type labels are not permitted. The labels shall be of adequate size to accommodate the

circumference of the cable being labeled and properly self-laminate over the full extent of the printed area of the label.

C. Tape (phase identification only): in appropriate colors for system voltage and phase.

D. Adhesive-type labels not permitted except for phase and wire identification.

PART 3 - EXECUTION

3.01 GENERAL

A. Where mixed voltages are used in one building (e.g. 480 volt, 208 volt) each switch, switchboard, junction box, equipment, etc., on each system must be labeled for voltage in addition to other requirements listed herein.

B. All branch circuit and power panels must be identified with the same symbol used in circuit directory in main distribution center.

C. Clean all surfaces before attaching labels with the label manufacturer's recommended cleaning agent.

D. Install all labels firmly as recommended by the label manufacturer.

E. Labels shall be installed plumb, level, and neatly on all equipment.

F. Install nameplates parallel to equipment lines.

G. Secure nameplates to equipment fronts using screws, or rivets.

H. Secure nameplate to inside of recessed panelboards in finished locations.

I. Embossed tape will not be permitted for any application.

3.02 JUNCTION AND PULL BOX IDENTIFICATION

A. The following junction and pull boxes shall be identified utilizing spray painted covers:

1. Secondary Power – 480Y/277V - Brown
2. Secondary Power – 208Y/120V, 240/120V - White
3. Fire Alarm - Red
4. Temperature Control - Green
5. Door Control and Door Monitoring System -Orange
6. Sound and Intercom Systems -Blue
7. Video Surveillance System/MATV – Yellow

3.03 COMMUNICATIONS SYSTEM IDENTIFICATION AND LABELING

A. Refer to Norfolk Southern "NS Copper and Fiber Optic Cabling Standards" for labeling instructions.

3.04 COMMUNICATION BACKBONE, RISER AND TIE CABLE LABELING

A. Refer to Norfolk Southern "NS Copper and Fiber Optic Cabling Standards" for labeling instructions.

3.05 INNERDUCT LABELING

A. Refer to Norfolk Southern "NS Copper and Fiber Optic Cabling Standards" for labeling instructions.

3.06 COMMUNICATION CONDUIT LABELING

A. All conduits installed between Telecommunication Rooms shall be clearly labeled in accordance with ANSI/TIA/EIA-606. Both ends of the conduits shall be labeled. All labels shall be mechanical, no hand written labels. The label shall indicate the location of the far end of the conduit run and a unique conduit number. (i.e. TR-1A-01 or Room #216 – 01).

3.07 POWER AND CONTROL WIRE IDENTIFICATION

A. Provide wire markers on each conductor in panelboard gutters, pull boxes, outlet and junction boxes, and at load connection. Identify with branch circuit or feeder number for power and lighting circuits, and with control wire number as indicated on schematic and interconnection diagrams or equipment manufacturer's shop drawings for control wiring.

B. All wiring shall be labeled within 2 to 4 inches of terminations. Each end of a wire or cable shall be labeled as soon as it is terminated including wiring used for temporary purposes.

3.08 NAMEPLATE ENGRAVING

A. Provide nameplates of minimum letter height as scheduled below.

B. Panelboards, Switchboards and Motor Control Centers: 1 inch (25 mm); identify equipment designation. 1/2 inch (13 mm); identify voltage rating, source and room location of the source.

C. Equipment Enclosures: 1 inch (25 mm); identify equipment designation.

D. Circuit Breakers, Switches, and Motor Starters in Panelboards or Switchboards or Motor Control Centers: 1/2 inch (13 mm); identify circuit and load served, including location.

E. Individual Circuit Breakers, Disconnect Switches, Enclosed Switches, and Motor Starters: ½ inch (13 mm); identify source and load served.

F. Transformers: 1 inch (25 mm); identify equipment designation. 1/2 inch (13 mm); identify primary and secondary voltages, primary source, and secondary load and location.

3.09 PANELBOARD DIRECTORIES

A. Typed directories for panels must be covered with clear plastic, have a metal frame. Room number on directories shall be Owner's numbers, not Plan numbers unless Owner so specifies. Hand written panel directories are not permitted.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement should be made as per-each type of item.

4.02 PAYMENT

A. The cost of complying with each section of this Specification is included in other bid items.

END OF SECTION

PART 1 - GENERAL

1.01 SCOPE

A. These specifications describe outdoor dry-type transformers. Transformers shall be built in accordance with applicable ANSI standards, except where specific requirements of these specifications shall take precedence.

1.02 RELATED SPECIFICATIONS

A. Section 16195 – Electrical Identification

1.03 CODES AND STANDARDS

A. Manufactured according to applicable standards:

1. NEC - National Electrical Code
2. IEEE - Institute of Electrical and Electronics Engineers
3. NEMA - National Electrical Manufacturer's Association
4. UL - Underwriters Laboratories, Inc.
5. ANSI - American National Standards Institute
6. NFPA – National Fire Protection Association

B. Design Criteria

1. Design ambient temperature 60°C.
2. Plant elevation less than 3300 ft.
3. Seismic zone 1.

1.04 SUBMITTALS

A. Shop Drawings: Submit shop drawings to Engineer for approval prior to construction. The following information shall be submitted to the Engineer.

1. For review - 1 week after Purchaser's release of each item for engineering.
2. Certified - 1 week after postmark of Owner's return of review drawings.

B. Required drawings for review.

1. Master drawing index and symbols.
2. Front view elevation.
3. Plan view.
4. Single line.

5. Schematic diagram.
6. Nameplate schedule.
7. Component list.
8. Conduit entry/exit locations and dimensions.
9. Cable terminal sizes and ratings.
10. Dimensioned outlines.
11. Weights.
12. Foundation details.

C. Certified Drawings: Vendor to provide 6 sets of certified drawings: 4 sets to be sent to the Construction Manager, 1 set to the Engineer and 1 set with equipment.

D. Certified information required.

1. Items from 1.04 B.3 (above)
2. Spare parts list and recommended spare parts.
3. Instructions for installation, operation and maintenance. Combine instructions for all electrical equipment, supplied by Vendor, into bound volumes.
4. Equipment names, per drawings that are covered by the manual.

1.05 DELIVERY, STORAGE AND HANDLING (BY OTHERS)

A. Purchaser will establish delivery dates as items are released for engineering.

B. Vendor shall notify Owner's Representative two weeks prior to shipment to schedule in-plant inspection and checkout.

1.06 TESTING

A. The following standard factory tests shall be performed on the equipment provided under this Section. All tests shall be in accordance with the latest applicable ANSI and NEMA standards.

1. Resistance measurements of all windings on the rated voltage connection of each unit and at the tap extremes of one unit only of a given rating on this project.
2. Ratio tests on the rated voltage connection and on all tap connections.
3. Polarity and phase-relation tests on the rated voltage connections.
4. No-load loss at rated voltage on the rated voltage connection.
5. Exciting current at rated voltage on the rated voltage connection.
6. Impedance and load loss at rated current on the rated voltage connection of each unit and on the tap extremes of one unit only of a given rating on this project.

7. Applied potential test.
8. Induced potential test.

B. The Manufacturer shall provide three (3) certified copies of factory test reports.

1.07 GUARANTEE

A. Vendor shall guarantee his equipment against faulty material and workmanship for 18 months after shipment or 12 months from time of operating acceptance by Owner.

B. Upon notice, the Vendor shall repair or replace, within the above warranty period, any of his equipment which is faulty.

1.08 SHIPMENT

A. Transformers shall be shipped in packaging suitable for outdoor storage of unit.

PART 2 - PRODUCTS

2.01 TRANSFORMER

A. The ratings of the transformer shall be as follows or as shown on the contract drawings:

kVA Rating as shown, OA	
Impedance	5.75% +/- 7 ½% ANSI Standard Tolerance
HV	12.47 kV Delta
HV BIL	60 kV
HV Taps	2 - 2 ½% full capacity above and below rated voltage
LV	4.160 kV Wye, 480V/277V Wye
LV BIL	10 kV, 60 kV

B. Construction:

1. Transformer shall be cooled by natural air convection (AA), and shall be equipped for future forced air (FFA) cooling. The unit shall include all necessary wiring and the relay required for the automatic control of future fans (not included) to increase the kVA rating by 33%. The FFA package shall include an electronic temperature monitor and fan control unit. The temperature monitor and fan control relay shall include digital readout, GREEN -- power on, YELLOW -- fan on, RED -- high temperature indicating lights; audible high temperature alarm with alarm silence pushbutton; maximum temperature memory with read and reset switch; auto/manual fan control switch, system test switch; temperature sensing in all three low-voltage coils. Auxiliary alarm contact and means for remote control and temperature monitoring shall be provided. Control power shall be provided by a separate, external control power source, to be installed by others in the future.
2. The electrical insulation system shall utilize class H material in a fully rated 220 degree C system. Transformer design temperature rise shall be based on a 30 degrees C average ambient over a 24-hour period with a maximum of 60 degrees C. Solid insulation in the

transformer shall consist of inorganic materials such as glass fiber, electrical grade epoxy and Nomex-type material. All insulating materials must be rated for continuous 220 degree C duty. The insulation between high voltage and low voltage cables shall be sufficient for rated voltage stresses without the need for a varnish.

3. The transformer shall be designed for a temperature rise of maximum 150 degrees C upon overload, and must fit within the allowed space as shown on the drawings.
4. The transformer shall be designed to meet the sound level standards for dry transformers as defined in NEMA TR1.
5. The transformer shall be UL labeled.
6. The transformer shall be of explosion resistant, fire-resistant, air-insulated, dry-type construction, and cooled by the natural circulation of air through the windings.

C. Windings

1. Delta connected, high voltage primary winding, 3 phase, 60 HZ.
2. Solidly grounded wye connected low voltage secondary windings, 3 phase, 60 HZ.
3. All windings are to be copper.
4. The high and low voltage coil assemblies shall be Vacuum Pressure Encapsulated.

D. Standard Features

1. The transformer shall be of heavy gauge sheet steel construction, equipped with removable panels for access to the core and coils. All exposed panels shall incorporate ventilating grills.
2. Pulling eyes and jacking facilities.
3. Designed for rolling or skidding in any direction.
4. Diagrammatic nameplate, stainless steel.
5. Removable case panel for access to high voltage strap-type connector taps for de-energized tap changing.
6. Two ground pads.
7. 6 kV distribution class surge arrestors shall be provided and connected at the incoming terminations and securely grounded to the ground bus.

2.02 ENCLOSURES

A. The enclosures shall be rated NEMA 3R for installation outdoors. All louvers and openings shall be fully protected from entry by outside elements. All seams shall be fully gasketed.

B. The enclosure shall be assembled with tamper-resistant hardware.

C. Enclosure shall be Category “B” per ANSI C57.12.55-1987, rated for installation in an unfenced area in a secured industrial complex.

D. The enclosure shall include a solid bottom to allow for placement of the unit on grating.

2.03 PAINT FINISH

A. The transformer enclosure shall be painted utilizing an initial phosphatizing cleaning treatment, followed by manufacturer's standard paint process baked on to a total of three (3) to five (5) mils average thickness. Unit shall be painted ANSI 61 for outdoor service.

PART 3 - EXECUTION

3.01 FACTORY TESTING

A. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest applicable ANSI and NEMA standards.

1. Resistance measurements of all windings on the rated voltage connection.
2. Ratio tests on the rated voltage connection and on all tap connections.
3. Polarity and phase-relation tests on the rated voltage connections.
4. No-load loss at rated voltage on the rated voltage connection.
5. Exciting current at rated voltage on the rated voltage connection.
6. Impedance and load loss at rated current on the rated voltage connection.
7. Applied potential test.
8. Induced potential test.

B. The Manufacturer shall provide three (3) certified copies of factory test reports.

3.02 INSTALLATION

A. Receive transformers from manufacturer and inspect thoroughly for damage and completeness. Report any damage to Engineer.

B. Install transformer on Platform as shown on the Contract Drawings.

C. Install all equipment per manufacturer’s recommendations and as shown on the Contract Drawings.

D. Contractor shall furnish and install all necessary hardware to secure the assembly in place.

E. Contractor shall verify platform layout and clearances with actual equipment dimensions prior to installation to ensure all clearances are maintained. Report any discrepancies to Engineer.

F. Install grounding and all phase conductors per manufacturer’s recommendations and as shown on the contract drawings. Torque connections per NEMA standards and Manufacturer’s recommendations.

G. Verify that all ventilation openings are free and unrestricted.

3.03 FIELD QUALITY CONTROL

A. As a separate line item in the bid breakdown, provide the services of a qualified factory-trained

Manufacturer's Representative to assist the Contractor in installation and start-up of the equipment specified under this section for a period of 1 working day. The Manufacturer's Representative shall provide technical direction and assistance to the Contractor in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained herein.

3.04 FIELD ADJUSTMENTS

A. Adjust taps to deliver appropriate secondary voltage.

B. Field testing

1. Measure primary and secondary voltages for proper tap settings.
2. Megger primary and secondary windings.

3.05 MANUFACTURER'S CERTIFICATION

A. A qualified factory-trained Manufacturer's Representative shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations. Equipment shall be inspected prior to the generation of any reports.

B. The Contractor shall provide three (3) copies of the Manufacturer's Representative's certification.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement should be made as per-each size of transformer.

4.02 PAYMENT

A. Payment shall be per each transformer.

B. Payment shall include furnishing, installing, transporting, labor, incidental materials, grounding, testing, etc. for a complete installation.

END OF SECTION

PART 1 - GENERAL

1.01 SCOPE

A. These specifications describe outdoor dry-type transformers. Transformers shall be built in accordance with applicable ANSI standards, except where specific requirements of these Specifications shall take precedence.

1.02 RELATED SPECIFICATIONS

A. Section 16195 – Electrical Identification

1.03 CODES AND STANDARDS

A. Manufactured according to applicable standards:

1. NEC - National Electrical Code
2. IEEE - Institute of Electrical and Electronics Engineers
3. NEMA - National Electrical Manufacturer's Association
4. UL - Underwriters Laboratories, Inc.
5. ANSI - American National Standards Institute
6. IPCEA - Insulated Power Cable Engineers Association
7. NFPA – National Fire Protection Association

B. Design Criteria

1. Design ambient temperature 60° C.
2. Plant elevation as shown on contract drawings.
3. Seismic zone as shown on contract drawings.

1.04 SUBMITTALS -- FOR REVIEW/APPROVAL

A. Shop Drawings: Submit shop drawings to the Engineer for approval prior to construction. The following information shall be submitted to the Engineer.

1. For review - 1 week after Purchaser's release of each item for engineering.
2. Certified - 1 week after postmark of Owner's return of Review Drawings.

B. Required drawings for review.

1. Master drawing index.
2. Front view elevation.
3. Floor plan.

4. Single line.
5. Schematic diagram.
6. Nameplate schedule.
7. Component list.
8. Conduit entry/exit locations.
9. Cable terminal sizes.
10. Dimensioned outlines.
11. Weights.
12. Foundation details.

1.05 SUBMITTALS -- FOR CLOSEOUT

A. Certified Drawings: Vendor to provide 6 sets of certified drawings: 4 sets to be sent to Construction Manager, 1 set to consulting engineer and 1 set with equipment.

B. Certified information required.

1. Items from 1.04 B. 3. (above)
2. Spare parts list and recommended spare parts.
3. Instructions for installation, operation and maintenance. Combine instructions for all electrical equipment, supplied by Vendor, into bound volumes.
4. Equipment names, per drawings that are covered by the manual.
5. Certified production test reports

1.06 DELIVERY, STORAGE AND HANDLING

A. Owner will establish delivery dates as items are released for engineering.

B. Vendor shall notify Owner's Representative two weeks prior to shipment to schedule in-plant inspection and checkout.

C. Bid "per specifications" with exceptions. A bid which rewrites this Specification or lists equipment being proposed is not acceptable. Vendor is encouraged to submit alternatives in addition to the required primary proposal.

D. Quote firm price and delivery, freight included, FOB job site. In addition, if shipment tracing and claim filing is available from Vendor, he is encouraged to quote FOB factory with freight allowed to job site.

E. After the order is placed, changes, additions and deletions to the order shall be made at the quoted multipliers with the price lists used at the time of quoting. These price lists shall be identified in the Vendor's proposal.

F. Quote as line items, field assistance during installation and start-up as well as training Owner's

personnel.

G. Test reports will be required. Itemize the change in price, if any, for these tests.

1.07 TESTING

A. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest applicable ANSI and NEMA standards.

1. Resistance measurements of all windings on the rated voltage connection of each unit and at the tap extremes of one unit only of a given rating on this project.
2. Ratio tests on the rated voltage connection and on all tap connections.
3. Polarity and phase-relation tests on the rated voltage connections.
4. No-load loss at rated voltage on the rated voltage connection.
5. Exciting current at rated voltage on the rated voltage connection.
6. Impedance and load loss at rated current on the rated voltage connection of each unit and on the tap extremes of one unit only of a given rating on this project.
7. Applied potential test.
8. Induced potential tests.

B. The Manufacturer shall provide three (3) certified copies of factory test reports.

1.08 GUARANTEE

A. Vendor shall guarantee his equipment against faulty material and workmanship for 18 months after shipment or 12 months from time of operating acceptance by Owner, whichever comes first.

B. Upon notice, the Vendor shall repair or replace in a reasonable period of time, any of his equipment which is faulty.

1.09 SHIPMENT

A. Transformers shall be shipped in packaging suitable for outdoor storage of unit.

PART 2 - PRODUCT

2.01 TRANSFORMER RATINGS

A. The ratings of the transformer shall be as follows or as shown on the contract drawings:

kVA Rating as shown, OA	
Impedance	5.75% +/- 7 ½% ANSI Standard Tolerance
HV	12.47 kV Delta
HV BIL	60 kV
HV Taps	2 - 2 ½% full capacity above and below rated voltage

LV	4.160 kV Wye, 480V/277V Wye
LV BIL	10 kV, 60 kV

2.02 CONSTRUCTION

A. The unit shall be silicone/high fire point liquid filled and shall be in accordance with the latest edition of the NEC. High fire point fluids shall be Factory Mutual and UL approved.

B. The transformer shall carry its continuous rating with average winding temperature rise by resistance that shall not exceed 55 degrees C, based on average ambient of 30 degrees C over 24 hours with a maximum of 60 degrees C. The insulation system shall allow an additional 12% kVA output at 65 degrees C average winding temperature rise by resistance, on a continuous basis, without any decrease in normal transformer life.

C. The transformer shall be designed to meet the sound level standards for liquid transformers as defined in NEMA and ANSI.

D. High-voltage and low-voltage windings shall be copper. Insulation between layers of the windings shall be by thermally set insulating paper or equal.

E. The main transformer tank and attached components shall be designed to withstand pressures greater than the required operating design value without permanent deformation. Construction shall consist of carbon steel reinforced with external, internal or sidewall braces. All seams and joints shall be continuously welded.

F. The assembly shall be individually welded and receive a quality control pressurized check for leaks. The entire tank assembly shall receive a similar leak test before tanking. A final six-hour leak test shall be performed.

G. The transformer(s) shall be compartmental-type, self-cooled and tamper-resistant for mounting on a pad. The unit shall restrict the entry of water (other than flood water) into the compartments so as not to impair its operation. There shall be no exposed screws, bolts or other fastening devices which are externally removable.

H. The transformer(s) shall consist of a transformer tank and full-height, bolt-on high- and low-voltage cable terminating compartments located side-by-side separated by a rigid metal barrier. Each compartment shall have separate doors, designed to provide access to the high-voltage compartment only after the low-voltage has been opened. There shall be at least one additional fastening device accessible only after the low-voltage door has been opened, which must be removed to open the high-voltage door. Doors shall be mounted flush with the cabinet frame. The low-voltage door shall have a handle-operated, three-point latching mechanism designed to be secured with a single padlock. A hex-head or penta-head bolt shall be incorporated into the low-voltage door latching mechanism. Both high and low-voltage doors shall be incorporated into the low-voltage door latching mechanism. Both high and low-voltage doors shall be equipped with stainless steel hinges and door stops to secure them in the open position.

I. Compartment sills, doors and covers shall be removable to facilitate cable pulling and installation. The high-voltage door shall be on the left with the low-voltage door on the right. Compartments shall be designed for cable entry from below.

J. Transformer(s) shall be supplied with a welded or bolted main tank cover and be of a sealed-tank construction designed to withstand a pressure of 7 psig without permanent distortion. The tank cover shall be designed to shed water and be supplied with a tamper-resistant access handhole

sized to allow access to internal bushing and switch connections. Transformers supplied with "less flammable" fluids, (high-molecular-weight hydrocarbon or silicone), shall be manufactured to withstand 12 psig without rupture. The transformer shall remain effectively sealed for a top-oil temperature of -5 degrees C to 105 degrees C. When necessary to meet the temperature rise rating specified, cooling panels shall be provided.

K. The transformer manufacturer shall certify that the transformer is non-PCB containing less than 1 part per million detectable PCBs. Nonflammable transformer liquids including Askarel and insulating liquids containing tetrachloroethylene, perchloroethylene, chlorine compounds, or halogenated compounds are not acceptable and shall not be provided.

L. Full-capacity taps shall be provided with a tap changing mechanism designed for de-energized operation. The tap changer operator shall be located within one of the compartments.

M. The coil windings shall be designed to reduce losses and manufactured with the conductor material as specified above. All insulating materials shall be rated for 120 degrees C class.

N. The core material shall be high-grade, grain-oriented, non-aging silicon core steel with high magnetic permeability, low hysteresis and eddy current losses. Magnetic flux densities are to be kept well below saturation to allow for a minimum of 10 percent over voltage excitation. The cores shall be properly annealed to reduce stresses induced during the manufacturing processes and reduce core losses.

O. The core frame shall be designed to provide maximum support of the core and coil assembly. The core frame shall be welded or bolted to ensure maximum short-circuit strength.

P. The core and coil assembly shall be designed and manufactured to meet the short-circuit requirements of ANSI C57.12.90. The core and coil assembly shall be baked in an oven prior to tanking to "set" the epoxy coating on the insulating paper and remove moisture from the insulation prior to vacuum filling.

Q. Transformer shall be vacuum-filled with the appropriate fluid as indicated above. The process shall be of sufficient vacuum and duration to ensure that the core and coil assembly is free of moisture prior to filling the tank.

2.03 ACCESSORIES

A. Transformer features and accessories shall include:

1. Dial-type thermometer
2. Liquid level gauge
3. Pressure-vacuum gauge
4. Drain valve with sample valve
5. Pressure relief valve
6. Non-PCB label
7. Upper fill/filter press connection or valve
8. Gas sampling valve

2.04 PRIMARY CONNECTIONS

A. Transformer primary connections shall be live front bushings with NEMA spades or eyebolt terminals suitable for cable sizes shown on the drawings.

2.05 PAINT FINISH

A. The transformer enclosure shall be painted utilizing an initial phosphatizing cleaning treatment, followed by manufacturer's standard paint process baked on to a total of three (3) to five (5) mils average thickness. Unit shall be painted ANSI 61 for outdoor service.

PART 3 - EXECUTION

3.01 FACTORY TESTING

A. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest applicable ANSI and NEMA standards.

1. Resistance measurements of all windings on the rated voltage connection.
2. Ratio tests on the rated voltage connection and on all tap connections
3. Polarity and phase-relation tests on the rated voltage connections
4. No-load loss at rated voltage on the rated voltage connection
5. Exciting current at rated voltage on the rated voltage connection
6. Impedance and load loss at rated current on the rated voltage connection.
7. Applied potential test
8. Induced potential test

B. The Manufacturer shall provide three (3) certified copies of factory test reports.

3.02 INSTALLATION

A. Receive transformers from manufacturer and inspect thoroughly for damage and completeness. Report and damage to Engineer.

B. Install transformer on Platform as shown on the Contract Drawings.

C. Install all equipment per manufacturer’s recommendations and as shown on the Contract Drawings.

D. Contractor shall furnish and install all necessary hardware to secure the assembly in place.

E. Contractor shall verify platform layout and clearances with actual equipment dimensions prior to installation to ensure all clearances are maintained. Report any discrepancies to Engineer.

F. Install grounding and all phase conductors per manufacturer’s recommendations and as shown on the contract drawings. Torque connections per NEMA standards and manufacturer’s

recommendations.

G. Verify that all ventilation openings are free and unrestricted.

3.03 FIELD QUALITY CONTROL

A. As a separate line item in the bid breakdown, provide the services of a qualified factory-trained Manufacturer's Representative to assist the Contractor in installation and start-up of the equipment specified under this section for a period of 1 working day. The Manufacturer's Representative shall provide technical direction and assistance to the Contractor in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained herein.

3.04 FIELD ADJUSTMENTS

A. Adjust taps to deliver appropriate secondary voltage.

3.05 FIELD TESTING

A. Measure primary and secondary voltages for proper tap settings.

B. Megger primary and secondary windings.

3.06 MANUFACTURER'S CERTIFICATION

A. A qualified factory-trained Manufacturer's Representative shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations. Equipment shall be inspected prior to the generation of any reports.

B. The Contractor shall provide three (3) copies of the manufacturer's representative's certification.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement should be made as per each transformer.

4.02 PAYMENT

A. Payment shall be per transformer.

B. Payment shall include furnishing, installing, transporting, labor, incidental materials, grounding, testing, etc. for a complete installation.

END OF SECTION

PART 1 - GENERAL

1.01 SCOPE

A. The Contractor shall furnish and install the equipment as specified herein and as shown on the Contract Drawings.

1.02 RELATED SPECIFICATIONS

A. Section 16195 – Electrical Identification

1.03 CODES AND STANDARDS

A. NEC - National Electrical Code

B. IEEE - Institute of Electrical and Electronics Engineers

C. NEMA - National Electrical Manufacturer's Association

D. UL - Underwriters Laboratories, Inc.

E. ANSI - American National Standards Institute

F. NFPA – National Fire Protection Association

1.04 SUBMITTALS – FOR REVIEW/APPROVAL

A. The following information shall be submitted to the Engineer:

1. Master drawing index
2. Front view elevation
3. Floor plan
4. Top view
5. Single line diagram
6. Schematic diagram
7. Nameplate schedule
8. Component list
9. Conduit entry/exit locations
10. Assembly ratings including:
    a. Short-circuit rating
    b. Voltage
    c. Continuous current
    d. Basic impulse level for equipment over 600 volts

11. Major component ratings including:
    a. Voltage
    b. Continuous current
    c. Interrupting ratings
12. Cable terminal sizes
13. Product data sheets

B. Where applicable the following additional information shall be submitted to the Engineer:
1. Busway connection
    a. Connection details between close-coupled assemblies
    b. Composite floor plan of close-coupled assemblies
    c. Descriptive bulletins

1.05 SUBMITTALS – FOR CONSTRUCTION

A. The following information shall be submitted for record purposes:
1. Final as-built drawings and information for items listed in paragraph 1.04
2. Wiring diagrams
3. Certified productions test reports
4. Installation information including equipment anchorage provisions
5. Seismic certification as in section 1.06.C

B. The final (as-built) drawings shall include the same drawings as the Construction Drawings and shall incorporate all changes made during the manufacturing process.

1.06 DELIVERY, STORAGE AND HANDLING

A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

B. Each switchgear assembly shall be split into shipping groups for handling as indicated on the drawings or as the manufacturer's limitations dictate. Shipping groups shall be designed to be shipped by truck, rail or ship. Shipping groups shall be bolted to skids. Accessories shall be packaged and shipped separately. Each switchgear shipping group shall be equipped with lifting eyes for handling solely by crane.

C. Switchgear being stored prior to installation shall be stored so as to maintain the equipment in a clean and dry condition. If stored outdoors, indoor gear shall be covered and heated, and outdoor gear shall be heated.

1.07 GUARANTEE

A. Vendor shall guarantee his equipment against faulty material and workmanship as directed in the Instructions to Bidders section of these documents.

B. Upon notice, the Vendor shall repair or replace in a reasonable period of time, any of his equipment which is faulty.

1.08 OPERATION AND MAINTENANCE MANUALS

A. Ten (10) copies of the equipment Operation and Maintenance manuals shall be provided.

B. Operation and Maintenance manuals shall include the following information:

1. Instruction books and/or instruction leaflets
2. Recommended renewal parts list
3. Drawings and information required by section 1.06.

PART 2 - PRODUCTS

2.01 RATINGS

A. The 15-kV Switchgear assembly ratings shall be as follows:

1. Maximum Design Voltage 15.0 kV
2. Basic Impulse Level 95 kV
3. Nominal System Voltage 13.8 kV three-phase
4. System Grounding Solid
5. Main Bus Continuous Current 200 Amperes
6. Short-Circuit Current at 14 kA RMS SYM Rated Maximum kV

2.02 CONSTRUCTION

A. The switchgear assembly shall consist of deadfront, completely metal-enclosed vertical sections containing load interrupter switches and fuses (where shown) of the number, rating and type noted on the drawings or specified herein.

B. The following features shall be supplied on every vertical section containing a three-pole, two-position open-closed switch:

1. A high-impact viewing window that permits full view of the position of all three switch blades through the closed door
2. The door shall be interlocked with the switch so that:
   a. The switch must be opened before the door can be opened
   b. The door must be closed before the switch can be closed.

3. A hinged grounded metal barrier that is bolted closed in front of every switch to prevent inadvertent contact with any live part, yet allows for a full-view inspection of the switch blade position
4. Provision for padlocking the switch in the open or closed position
5. Green OPEN, Red CLOSED switch position indicators with the words "Open" and "Closed" in Spanish and English
6. A hinged cover with over the switch operating mechanism to discourage casual tampering

C. Vertical section construction shall be of the universal frame type using die-formed and bolted parts. All enclosing covers and doors shall be fabricated from steel whose thickness shall be equal to or greater than those specified in ANSI/IEEE C37.20.3. To facilitate installation and maintenance of cables and bus in each vertical section, a removable top cover and hinged rear door latched closed by tamper-resistant pad lockable latches shall be provided.

D. Each vertical section containing a switch shall have a single, full-length, flanged front door and shall be equipped with two (2) rotary latch-type pad lockable handles. Provision shall be made for operating the switch and storing the removable handle without opening the full length door.

E. Each load interrupter switch shall have the following features:

1. Three-pole gang-operated mechanism
2. Manual quick-make, quick-break over-toggle-type mechanism that does not require the use of a chain or a cable for operation, and utilizes a heavy-duty coil spring to provide opening and closing energy
3. The speed of opening and closing the switch shall be independent of the operator, and it shall be impossible to tease the switch into any intermediate position under normal operation
4. Separate main and break contacts to provide maximum endurance for fault close and load interrupting duty
5. Insulating barriers between each phase and between the outer phases and the enclosure
6. A maintenance provision for slow closing the switch to check switch blade engagement and slow opening the switch to check operation of the arc interrupting contacts.

2.03 BUS

A. All phase bus conductors shall be tin plated copper.

B. Ground bus shall be silver-plated copper and be directly fastened to the adjacent vertical section bus as well as the galvanized metal surface of each vertical section, and be of a size sufficient to carry the rated current of the switchgear assembly.

C. All standoff insulators on switches and fuse mountings shall be Polykeram, or equal.

2.04 WIRING/TERMINATIONS

A. One (1) terminal pad per phase shall be provided for attaching Contractor-supplied cable terminal lugs for a maximum of two (2) conductors per phase of the sizes indicated on the drawings. Sufficient space shall be allowed for contractor supplied electrical stress relief termination devices.

2.05 FUSES

A. Fault protection shall be provided by fuses with continuous ratings as shown in the contract documents. Furnish three (3) spare fuses for each fused switch. Any fuse/switch integrated momentary and fault close ratings specified shall have been verified by test and UL and CSA certified.

2.06 ENCLOSURES

A. The switchgear described in these specifications shall be weatherproof for outdoor service and shall be mounted upon an integral base frame with a weatherproof enclosure assembly for a complete metal enclosed switchgear assembly.

B. Each vertical section of outdoor switchgear shall be provided with space heaters. Tubular type heaters operated at half voltage for long life shall be supplied. 500-volt rated heaters shall be used at 240 volts. Power for space heaters shall be furnished from a control power transformer mounted in the switchgear.

C. Heaters shall be wired to provide temporary heating during storage.

D. The enclosure shall be gasketed, sealed, and formed using techniques to close off all openings, ensuring that the interior remains dry and free of contaminants and eliminating points of purchase. All enclosures feature comprehensive access controls and security measures to guard against unauthorized entry.

2.07 NAMEPLATES

A. Engraved nameplates, mounted on the face of the assembly, shall be furnished for all main and feeder circuits. Nameplates shall be secured with screws. Furnish master nameplate for each switchgear lineup giving information in accordance with IEEE Std C37.20.2-1999, section 7.4.1. Circuit nameplates shall be provided with circuit designations as shown on purchaser's single-line diagrams.

B. Provide nameplates as directed in specification section 16040.

2.08 FINISH

A. The finish shall consist of a coat of gray (ANSI-61), thermosetting, polyester powder paint applied electro statically to pre-cleaned and phosphatized steel and aluminum for internal and external parts. The coating shall have corrosion resistance of 600 hours to 5% salt spray.

PART 3 - EXECUTION

3.01 FACTORY TESTING

A. The following standard factory tests shall be performed on the circuit breaker element provided under this section. All tests shall be in accordance with the latest version of ANSI standards.

1. Alignment test with master cell to verify all interfaces and interchangeability
2. Circuit breakers operated over the range of minimum to maximum control voltage
3. Factory setting of contact gap
4. One-minute dielectric test per ANSI standards
5. Final inspections and quality checks

B. The following production test shall be performed on each breaker housing:

1. Alignment test with master breaker to verify interfaces
2. One minute dielectric test per ANSI standards on primary and secondary circuits
3. Operation of wiring, relays and other devices verified by an operational sequence test
4. Final inspection and quality check

C. The Manufacturer shall provide three (3) certified copies of factory test reports

D. Factory tests as outlined above under 3.02.B shall be witnessed by the Owner's Representative.

1. The Manufacturer shall notify the owner two (2) weeks prior to the date the tests are to be performed.
2. The Manufacturer shall include as a separate line item the cost of performing FAT tests before up to three Owner Representatives.

3.02 FIELD QUALITY CONTROL

A. As a separate line item, provide the services of a qualified factory-trained Manufacturer's Representative to assist the Contractor in installation and start-up of the equipment specified under this section for a period of 3 working days. The Manufacturer's Representative shall provide technical direction and assistance to the Contractor in general assembly of the

equipment, connections and adjustments, and testing of the assembly and components contained therein.

B. The Contractor shall provide three (3) copies of the Manufacturer's field start-up report.

3.03 MANUFACTURER'S CERTIFICATION

A. Under the Field Quality Control inspection listed above, a qualified factory-trained Manufacturer's Representative shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the Manufacturer's recommendations.

B. The Contractor shall provide three (3) copies of the Manufacturer Representative's certification.

3.04 TRAINING

A. As a separate line item, provide a training session for up to five (5) owner's representatives for one (1) normal workday at the jobsite location determined by the owner.

B. The training session shall be conducted by a Manufacturer's qualified representative. Training program shall include instructions on the assembly, circuit breaker, protective devices, and other major components.

3.05 INSTALLATION

A. The Contractor shall install all equipment per the Manufacturer's recommendations and Contract Drawings.

B. The Contractor shall provide all hardware to secure the assembly in place.

3.06 FIELD ADJUSTMENTS

A. The relays shall be set in the field by a qualified representative of the Manufacturer.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement should be made as per each switchgear assembly.

4.02 PAYMENT

A. Payment shall be per switchgear assembly.

B. Payment shall include furnishing, installing, transporting, labor, incidental materials, grounding, testing, etc. for a complete installation.

END OF SECTION

PART 1 - GENERAL

1.01 SCOPE

A. Provisions of this Section shall apply to all fuses and fused equipment of greater than 600 Volts as shown on the Drawings. Provide general purpose type current limiting expulsion fuses as shown on the Drawings. The fuses shall be designed to operate with the load interrupter switchgear and medium voltage motor starters and shall be tested and rated in accordance with the current ANSI standards.

B. Furnish and install all fuses as described herein.

1.02 RELATED SPECIFICATIONS

A. Section 16349 – Medium Voltage Gear and Starters

1.03 CODES AND SPECIFICATIONS

A. NEC - National Electrical Code

B. IEEE - Institute of Electrical and Electronics Engineers

C. NEMA - National Electrical Manufacturer's Association

D. UL - Underwriters Laboratories, Inc.

E. ANSI - American National Standards Institute

F. NFPA – National Fire Protection Association

1.04 SUBMITTALS – FOR REVIEW/APPROVAL

A. The following information shall be submitted to the Engineer:

1. Major component ratings including:

a. Voltage

b. Continuous Current

c. Interrupting Ratings – rms Amperes, Symmetrical

d. Descriptive Bulletins

e. Product data

1.05 SUBMITTALS – FOR CONSTRUCTION

A. The following information shall be submitted for record purposes:

1. Major component ratings including:

a. Information for items listed in paragraph 1.04

b. Installation information

1.06 DELIVERY, STORAGE, AND HANDLING

A. Medium-voltage fuses shall be stored in a non-condensing environment between 10 degrees C and 40 degrees C.

B. Equipment shall be handled and stored in accordance with Manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

1.07 OPERATION AND MAINTENANCE MANUALS

A. The following Equipment Operation and Maintenance manuals shall be provided with each assembly shipped, and shall include instruction leaflets and instruction bulletins for the complete assembly and each major component.

PART 2 - PRODUCTS

2.01 RATINGS

A. Fuse

1. ANSI Designation: C
2. Fuse Type: CLE
3. Nominal System Voltage: 13800V, 4160V
4. Maximum Design Voltage: 15000V, 5500V
5. Current Rating: See Contract Drawings
6. Interrupting Rating: 40kAIC

2.02 CONSTRUCTION

A. The following features shall be included on every current limiting fuse:

1. High purity, graded silica-sand filler with pure silver (.999 fine) elements encased in a glass epoxy casing.

B. The following shall be included on every boric acid expulsion fuse:

1. Fuse refill shall be hermetically sealed to prevent water ingress
2. Fuse casing shall be glass-epoxy.

2.03 MAIN DEVICES

A. CLE Type Fuses

1. 15 kV fuses, through 300E shall be 3 inches in diameter and shall be 17-7/8 inches in length.

PART 3 - EXECUTION

3.01 SPARE FUSES

A. Furnish one set of three spare fuses for each size and type of fuse used. Spare fuses shall be turned over to Owner's Representative.

3.02 FACTORY TESTING

A. The manufacturer shall supply, upon request, test results that show the high-voltage fuse design has been tested to the applicable ANSI and NEMA standards. All fuses shall be checked 100% for correct resistance values.

3.03 INSTALLATION

A. The contractor shall install all equipment per the Manufacturer's recommendations and the Contract Drawings.

B. All necessary hardware to secure the assembly in place shall be provided by the Contractor.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement should be made as per-each type of item.

4.02 PAYMENT

B. The cost of complying with each section of this Specification is included in other bid items.

END OF SECTION

PART 1 - GENERAL

1.01 SCOPE

A. Overhead electric system construction

B. Furnishing necessary equipment and incidental materials to install the specified assemblies in the quantities required by the Contract Drawings and these Specifications to provide a complete and working installation.

C. Basic methods and test reports.

D. Installation of suitable aggregate, concrete, or earth backfill.

E. Removals of existing facilities as shown in the Contract Drawings.

1.02 RELATED SPECIFICATIONS

A. Section 16372 – Overhead Line Materials

1.03 CODES AND STANDARDS

A. NEC - National Electrical Code

B. IEEE - Institute of Electrical and Electronics Engineers

C. NEMA - National Electrical Manufacturer's Association

D. UL - Underwriters Laboratories, Inc.

E. ANSI - American National Standards Institute

F. IPCEA - Insulated Power Cable Engineers Association

G. NFPA – National Fire Protection Association

1.04 SUBMITTALS

A. Submittal information and shop drawings shall be submitted for approval.

B. Sagging method chosen, proposed procedure, and test results.

C. Aggregate gradation purchase document.

D. Concrete mixture purchase document with certification.

1.05 ASSEMBLY GUIDE DRAWINGS AND PROJECT CONSTRUCTION DRAWINGS

A. The Construction Drawings are diagrammatic indicating major items of materials and general arrangement of assemblies to establish a standard of construction.

B. Conditions encountered in the field may vary from those shown on Contract Drawings, and the construction shall be modified as required to accommodate the field conditions involved. The general arrangement of circuits and clearances indicated on the assembly guide drawings shall be maintained. The Engineer shall approve any deviation from Contract Drawings prior to construction.

1.06 ASSEMBLY UNIT BASIS

A. The Construction assemblies are on a unit basis so that the Owner may authorize any combination, addition or deletion, or construction units desired,

B. The descriptions apply to those assemblies on the project drawings and assembly guide drawings and include all necessary labor and incidental installation materials required to install the assemblies complete.

1.07 WARRANTY

A. All labor, materials, and equipment supplied under this specification shall be warranted as outlined in the GENERAL CONDITIONS.

PART 2 – PRODUCTS

2.01 COARSE AGGREGATES

A. ASTM C33 No. 67 gradation.

B. If filler, in addition to that naturally present in the aggregate material, is necessary for satisfactory compaction, it shall be uniformly blended with the aggregate material at the crushing plant.

C. If the additional filler is composed of sand, the amount of sand shall not exceed 20 percent by weight of the total combined aggregate.

2.02 CONCRETE

A. Portland Cement ASTM C150: Type 1.

B. Coarse and Fine Aggregates: ASTM C33.

C. Water: Clean and free of injurious amounts of oil, alkali, organic matter, or other deleterious materials.

D. Mix: Compressive Strength (7 day) 2100 psi. Compressive Strength (28 day) 4000 psi.

E. Provide air entraining admixture conforming to ASTM C260.

F. Slump: Three inch maximum, one inch minimum.

2.03 WEATHERING SEVERITY

A. Provide materials in accordance with ASTM C33 table 3 to the requirements for Class 3S weathering regions.

B. Do not use crushed concrete or recycled concrete for materials.

PART 3 – EXECUTION

3.01 GENERAL

1. Existing Underground Installations:

a. Existing underground installations such as water lines, gas mains, and sewers in the vicinity of pole foundation drilling locations are indicated on the Drawings only to the extent that such information has been made available to or discovered by the Owner/Engineer in preparing the Drawings. There is no guarantee as to the accuracy or completeness of such information and all responsibility for the accuracy and completeness thereof is expressly disclaimed.

b. The Contractor shall be solely responsible for locating all existing underground installations prior to drilling pole holes. The Contractor shall use his own information as shall not rely upon any information indicated on the Drawings concerning existing underground installations.

c. The Contractor will be held responsible for any interruption in the service of underground facilities resulting from his operations, unless the facilities owner has given specific approval for the interruption in each case.

d. Except where the damaged parties desire to conduct their own repair and restoration work, the Contractor shall repair and fully restore any underground facility damaged during the construction period to a condition equal to or better than that which existed at the time of damage. All repair and restoration work shall be done to the complete satisfaction of the damaged parties and the Owner.

e. The Contractor shall make his own arrangements with any jurisdictional authority requiring inspection of repaired or reconditioned utility facilities. All inspection fees applicable shall be paid by the Contractor.

f. Where the damaged parties desire to conduct their own repair and restoration work, the Contractor shall render all assistance to facilitate this corrective work. The Contractor shall assume all just and reasonable expenses thus incurred by the damaged parties.

B. Each underground facility encountered shall be accurately located on the Project Record Drawings, indicating the original location and relocation, if any. When all work is completed, the marked copy of the Drawings shall be submitted to the Owner as part of the field records.

3.02 POLE INSTALLATION

A. Handle poles carefully. Do not drop them from transportation vehicles. Use appropriate slings.

Steel tongs or other grips that cause damage to pole surfaces are not acceptable

B. The diameter of each pole hole shall be as required for compaction of backfill around the pole, but not less than the pole diameter at the butt plus 6 inches.

C. Pole hole excavation shall include removal of stumps, roots, and other obstructions as necessary to provide a clean hole to the required depth.

D. Poles shall be immediately set and plumbed after hole excavation.

E. The minimum setting depth shall be as follows:

Length of Setting Table

Pole, feet	Feet	Pole, feet	Feet	Pole, feet	Feet
25	5.0	55	7.5	85	10.5
30	5.5	60	8.0	90	11.0
35	6.0	65	8.5	95	11.5
40	6.0	70	9.0	100	12.0
45	6.5	75	9.5	105	12.5
50	7.0	80	10.0	110	13.0

1. On a sloping ground, measure the depth of the hole from the low side of the slope.
2. Each pole in single-pole structures and in multi-pole structures on level ground surfaces shall be set no greater than 3 inches of the depth specified in the preceding table. When conditions are encountered that warrants setting depths in excess thereof the Engineer shall be notified prior to setting the pole.

F. Pole hole excavation by hand digging, or other means shall be at the option of the Contractor.

G. Tamp thoroughly by mechanical method with earth backfill around the poles for the full depth of the hole. Mechanical tamping shall be in maximum 6-inch layers. Bank excess dirt up around the pole. Refill and thoroughly tamp to the ground line any settlement that occurs until completion of the Contract.

H. Poles shall be set in alignment and plumb with and across the line, except at angles where vertical suspension insulators or offset framing is used. Poles set on these type angles unless otherwise indicated shall be offset on the bisector of the angle so that the conductors shall hang directly over the point of intersection and in line with the poles in both directions either side of the angle.

I. Where rocks and gravel larger than 2 inches and without at least 50 per cent soil composition, and where swampy type soils are encountered in hole digging, this shall not be used as backfill. Do not use sod or grassy soil or place foreign objects in the backfill.

J. Each pole shall be set within 1-1/2 inches transversely of the location indicated on the Plans. Longitudinal location shall be within 1 foot. Vertical alignment of all poles shall be within 3 inch

of plumb.

K. When raking is specified, poles shall be raked one inch for each 10 feet of pole out of the ground. Poles shall be raked only upon prior approval from the Engineer.

3.03 WOOD POLES

A. Do not cut the top of poles except under very exceptional conditions and upon prior approval by the Engineer. If the top is cut, cover with an approved pole cap. Do not, under any circumstances, cut off the butt of any pole.

B. Do not frame poles that have sweeps or crooks across the line.

C. Plug all unused holes prior to pole erection using treated wood dowel pins. When holes are enlarged treat the hole with preservative compound of the same type as the pole treatment.

D. The Contractor shall field drill all bolt holes that are required for a complete installation. Where single members are bolted to more than two poles, holes in the center poles shall be drilled only after poles are set. Field drilled bolt holes shall be drilled using a bit with a diameter not larger than 1/16 inch the diameter of the bolt to be inserted.

E. Field drilled holes shall be in line with the strain or at right angles to the assembly they support. Assemblies mounted on uneven pole surfaces shall be adjusted with metal shims or gaining of poles as approved by the Engineer. All field drilled holes, gains, and cut surfaces shall be treated with a preservative compound of the same type as the pole treatment or a liberal amount of 5 percent pentachlorophenol or Copper naphthenate compound solution.

F. Gaining of poles, where required, shall be perpendicular to bolt holes and shall not exceed ¼-inch in depth.

G. All structures shall be framed and assembled as indicated on the drawings. Assembly procedures shall minimize the amount of pole climbing that must be done after the structure is set. Any pole which is badly spurred shall be shaved and brushed with a preservative acceptable to the Engineer.

3.04 TUBULAR STEEL

A. All structure components shall be handled with care to prevent damage to the finish. Padded cradles and nylon slings shall be used when handling the structures.

B. Tubular shafts which are shipped in more than one piece shall be assembled using two jacks placed on opposite sides of the shaft. Shaft assembly shall be performed according to the Manufacturer's instructions, drawings and recommendations.

C. Bolts:

1. Tightening of galvanized bolts shall be done by the "turn-of-nut" method only. A washer shall be used under the element to be turned in tightening.

2. Bolt installation and bolting tools and equipment shall be in accordance with the structure Manufacturer's recommendations. Nuts and bolts shall be handled and installed in a manner

that will not damage the galvanized finish. Wrenches which deform the nut or bolt head or which mar the galvanized finish shall be replaced by wrenches acceptable to the Engineer. The Contractor shall replace, without cost to the Owner, all bolts and nuts damaged during installation with new, undamaged bolts and nuts of the same type, size, and quality as the original bolts.

3. Bolted connections shall be drifted to proper position and the holes inspected to ensure that bolt threads will not be damaged by forcing the bolts in place.
4. The Contractor shall make a thorough inspection to ensure that all bolts are tightened and that a locknut has been installed and tightened on each bolt where required.
5. Any structure bolt which has been tightened shall not be loosened and re-tightened. Bolts which have been loosened after tightening shall be discarded and new bolts used in their place. New bolts shall be furnished by the Contractor at no cost to the Owner.

D. All damaged galvanized surfaces shall be cleaned of grease, scale, and all foreign matter and repaired with "AMCO 322 Galvanizing Sticks" or "AMCO 321 Galvanizing Powder" as manufactured by Force Chemicals Division of American Solder and Flux Co., Inc. of Paoli, Pennsylvania, or an acceptable equal material. The touchup galvanizing material shall be applied in strict accordance with the Manufacturer's application instructions to provide a uniformly coated surface. The Contractor shall furnish and apply the touchup galvanizing material to any surface where the galvanizing coating is broken or removed. Where practical, the galvanizing repair shall be done before the structures are set. Repair to galvanized surfaces damaged by the Contractor shall be at no cost to the Owner.

E. Where ground-line protection sleeves are furnished, they shall be centered at the standard depth that allows this protection sleeve to extend below and above the ground-line on individual poles. If the setting dimension or side hill slope causes the sleeve not to be 6" above or below the ground-line, the pole shall have a coating of bitumastic applied at ground-line to extend 1 foot above and below the ground-line.

F. Aggregate Placement:

1. Backfill aggregate shall be placed in compacted 6 inch lifts by means of mechanical or hydraulic tamping.
2. Bank aggregate around the structure to a height 6 inches above existing grade and taper to the edges of the backfilled hole. Refill and thoroughly tamp any settlement that occurs until completion of the contract.
3. Do no place foreign objects in backfill.

G. Concrete Placement:

1. Earthen formwork is to be used in stable soils. Where soils are unsuitable, use forms for round columns spirally constructed of laminated plies of fiber.
2. Slope the exposed concrete to drain away from structure with at least ½ inch of slope reaching to the outer limit of the filled area.
3. Form-work shall not be removed for 24 hours after placement.

H. Structure Stabilization:

1. Structures shall be stabilized by holding, guying, or bracing until placement of special backfill has been completed.

2. When concrete backfill is used the structure shall be supported for at least 72 hours, and no external loads shall be subsequently applied for at least 3 days.

I. When specified steel poles require ground conductor clips, attachments for ground conductor clips shall be welded to or drilled into pole. Attachments shall be 2' apart except for a distance of 8' above the lower grounding connection where they shall be 6" apart.

3.05 POLE-TOP ASSEMBLIES

A. Crossarms shall be installed as per the Manufacturer's installation instructions.

B. Level all support crossarms and conductor supports. Those on tangent construction shall be at right angles to the conductors they support. Balance the conductor loading equally between the supports.

C. Field drilled holes shall be in line with the strain or at right angles to the assembly they support. Assemblies mounted on uneven pole surfaces shall be adjusted with metal shims where practical.

D. Install assemblies and equipment rigid and secure, plumb and level, and in alignment with related and adjoining work. Welding or cutting of materials or deviation from Manufacturer recommendations for attachment or support shall be prohibited.

E. Where subsequent alteration, adjustment, or reworking of existing assemblies is required, it shall be performed using materials and workmanship to match those of the original installation; and restored at least to the conditions which existed, unless otherwise indicated.

F. Install new materials and equipment and connect to existing installations, where indicated, with minimum interference to existing facilities.

G. Align suspension units with the bisector of the line angle on vertical angle construction. Insure all cotter keys are in place in suspension units.

H. Extra care shall be exercised during all phases of construction to prevent scarring or abrading the surface of any assembly item. Ladders may be hung from assembly to simplify clipping-in operations; however, the ladder hooks shall be covered with a rubber hose or otherwise padded to prevent damage to the protective coating.

3.06 INSULATORS

A. Exercise care in handling and installing insulators and in assembling suspension units.

B. Each insulator unit shall be inspected and when installed shall be free of cracks, chips, bent pins, and other defects. Defective insulators shall be removed from the work site immediately.

C. All insulators installed shall have surfaces cleaned of all foreign material and porcelain insulators shall be wiped to a bright finish.

D. Install horizontal mounted insulators at right angles to the conductors they support.

E. Deadend insulator strings, when completely assembled, shall have all cotter pins fully seated. Deadend insulator strings must be attached to the structure after setting the poles. The insulator strings shall be hoisted into position with slings or wires in a manner so as not to cause damage.

F. When material items are mounted on each structure prior to setting the poles, the structures shall be supported off the ground before pole setting to maintain clean surfaces and to avoid damage to the assemblies.

3.07 CONDUCTORS AND APPURTENANCES

A. Stringing

1. All poles shall be plumb before stringing conductors.
2. Carefully handle conductors. Do not drag them over sharp objects nor allow them to be stepped upon or run over by vehicles. Avoid kinking, twisting or abrading the conductors in any manner. Inspect the conductor as it is unreeled for cuts, abrasions, and other injuries. Cut out the faulty sections and splice the conductor as required.
3. Install the conductors and accessories in accordance with Manufacturer's recommendation. Pull the conductors over suitable rollers or stringing blocks. Properly mount on the pole or crossarm to insure proper sagging. Prevent binding while stringing.
4. Conductors shall be strung by controlled-tension method using proper stringing blocks. Conductors larger than 1.0 inches in diameter and ACSR conductors of multiple stranded steel cores shall be strung using neoprene lined or similar type blocks. The stringing equipment shall have groove sizes that will in no way damage the conductor, and capable of maintaining preset tensions and pulling speed. Maintain sufficient continuous tension to keep conductors clear of the ground or obstructions that could cause damage to or by the conductor.
5. The tension on any conductor during stringing shall not exceed 50 percent of the ultimate strength of the conductor at the temperature existing at the time of stringing.
6. When, during the stringing operation, a conductor contacts another conductor, the ground, or some other object which might cause damage, the conductor shall be lowered, wiped clean, and closely inspected by the Engineer to determine the extent of damage. Depending on the severity of damage and the length of the damaged section, repairs shall be made by smoothing of the conductor with fine sandpaper or by cutting out the damaged section and splicing.
7. Locate the cable pullers, tensioners and pulling machines as near midspan as possible. In no case shall the slope of the conductor between the machine and the stringing block at the first structure be steeper than three horizontal to one vertical.

B. Sag Operations and Tests

1. The length of conductor sagged in one operation shall be limited to the length that can be sagged satisfactorily, or as approved by the Engineer.
2. Sag in as level and as average a ground span as possible.
3. Sag all conductors in accordance with Sag Tables that will be furnished by the Engineer.

Where new and existing conductors are strung together, sag both conductors with the sag tables, unless otherwise specified by the Engineer.

4. The Contractor may select one of three methods to sag conductor:
   a. Transit Method - Use of a transit to accurately measure the sag by calculated angle of sight method, calculated target method, or horizontal line of sight method.
   b. Dynamometer Method - Insertion of a dynamometer in line with the sagging equipment to verify actual tension of the line.
   c. Stopwatch or Time-Wave Method - measurement of return waves after striking or jerking the conductor to produce an initial wave.
5. In sagging one reel length, the sag of two spans shall be checked. In sagging lengths of more than one reel, the sag of three or more spans near each end and the middle of the length being sagged shall be checked. The length of the spans used for checking shall be approximately equal to the ruling span. At the option of the Engineer, all spans that exceed the ruling span by 25 percent or more shall be checked for sag; and, at sharp vertical angles, the sag shall be checked on both sides of the angle. The following spans are unacceptable for sagging tests:
   a. Inclined spans, tangent to vertical configurations, deadends, tangent to angles, spans with splices,
6. Sagging shall not be performed when wind or other adverse weather conditions prevent satisfactory sagging. Sagging shall not be performed at temperatures below 20 degrees Fahrenheit.
7. The air temperature at the time and place of sagging shall be determined by a certified Etched-glass or a highly accurate bimetal thermometer. Record the temperature at which the conductor is sagged and the spans in which sags are measured and furnish this information to the Engineer.
8. The Contractor shall verify the electrical clearances to foreign wire crossings or other supports after sagging operation is complete. Record clearances and submit to Engineer.

C. Clipping In

1. Clipping may begin as soon as the conductor has been sagged. Tape or ink mark a reference point on the conductor measured from the center of the stringing block location. After clipping-in verify that the conductor has not moved from its sagging point. Clipping should progress so as to avoid trapping uneven sags between clipped sections.
2. Long spans, inclined spans, and deadend spans shall be clipped in first, so as to minimize conductor movement. At the option of the Engineer, the Contractor may be directed to also clip in at the mid-point and one-quarter points of sagging operation.
3. Lifting of the conductors shall be done with a hoist and lifting hook that will not notch or severely bend the conductors. The conductor lifting hook should have an elastomer cover so as not to damage the surface of the conductors. The conductors shall not be lifted high enough such that the conductor will creep in adjacent spans.
4. Bundled conductors may be lifted simultaneously be the use of a yoke arrangement supporting the hooks and a single method of lifting.

5. Conductors shall NOT remain in lifting blocks for more than 72 hours to avoid damage to conductors or sheaves.
6. If shown on the Contract Drawings, dampers shall be installed immediately after clipping to prevent possible wind vibration damage.

D. Conductors shall be cut out and spliced in any location where damage on the cable has occurred. Repair sleeves may be used to repair damaged conductor when the damage is concentrated in a small area or when the number of broken strands is less than 10% of the strands on the outer layer. Any damaged location shall be reported to and reviewed by the Engineer, prior to repair.

3.08 SPLICES AND TIES

A. New conductors shall not have more than one splice per conductor in any span. Do not locate splices in new conductor within 10 feet of any conductor support. Cut out and re-splice improperly located splices, injured portions, crooked or imperfect splices. Do not leave bent or curved splices in the conductors.

B. Splices in new conductors shall not be located in NESC defined Grade B crossing spans. No extra pay will be made for any splices that may be required for any reason in existing conductors left in place.

C. Clean the contact surfaces thoroughly before splicing and carefully follow Manufacturer's recommendations. Use the proper die and crimping tool that is mated to the splice. Insure that the proper spacing and number of crimps are made.

D. Use the Manufacturer’s recommended inhibitor when splicing and installing connectors to aluminum conductors. Use a pressure gun with tapered nozzle to inject the inhibitor into splicing sleeves.

E. Splices and compression connectors on conductors larger than 0.60 inches diameter shall be hydraulically crimped. Automatic splices may be used, as approved, but only in full tension conductors.

F. When a bow (non-hex) die is used, the crimping tool is to be rotated 90 degrees between crimps in order to avoid banana bowing of the splice. If a connector bows it shall be cut out and replaced. It shall not be repaired by hammering on it.

G. Ties shall be of the type and configuration as required for the conductor and support used, and in accordance with the Contract Drawings. Tie wire shall be tightly drawn around the conductor support and armor rod so that no slack space occurs.

H. Pre-formed conductor ties may be used for re-working of energized conductors if approved. Hot line ties shall not be used.

3.09 LAMPS, JUMPERS, AND CONNECTORS

A. Use proper size connections and only those which will not cause galvanic action where conductors are of dissimilar metals. The contact surfaces of clamps and conductors shall be cleaned and bright using a steel brush as the principal cleaning medium. Where bolted connectors are approved the bolts shall be brought down hard, but the threads shall not be overstressed. Use a

suitable inhibitor on aluminum surfaces for all connectors, hot-line clamps, etc.

B. Exercise utmost care when installing parallel groove clamps where specified. Clean the contact surface of the clamp and the wire. Bolts shall be brought down hard, but the threads shall not be over stressed. Bolted clamps shall not be used on grounding connections.

C. Install hot-line clamps so that they are permanently bonded to the load side of the line, allowing the jumper to be de-energized when the clamp is disconnected from the supply line.

D. Allow sufficient, but not excessive slack in jumpers and other leads. Make them neat and uniform in appearance and in general run in horizontal and vertical planes with rounded turns. Support all jumpers to prevent excessive movement between supports and to clear all conflicts and maintain clearances as required by NESC. Do not use broom-stick coils in any jumpers.

E. At points of deadends, taps and take-offs of the main supply line, conductor tails shall be left long enough to be used as jumpers and such that splices or connections shall be limited to one per phase.

F. Existing conductors to be connected to transformers, line equipment, or other conductors shall be thoroughly cleaned and connections made as would be for new conductors.

G. Size each jumper, whether existing or new, to be at least as large as the conductor on the load side.

H. All line and service connections shall be made with compression connectors. Use of bolted connection shall have prior approval from the Engineer. Aluminum to copper connections shall be made with connectors suitable for use with dissimilar metals.

I. Service connections, with the exception of the neutral connection, shall be covered at the point of connection with black all-weather vinyl electrical tape, or a polyethylene plastic cover.

3.10 GROUNDS

A. Where ground rods are specified, drive ground rods the full length in undisturbed earth a minimum of 2'-0" from the surface of the pole, with the top of the rod and the grounding jumper a minimum of 1'-0" below natural grade. Install ground rods at all transformer and equipment locations and as shown in the Contract Drawings.

B. Interconnect all equipment grounds, neutral wires, and protective equipment and attach to a common pole ground wire. Make at least two (2) continuous connections on all equipment from the equipment frame or case of equipment tank to the multi-grounded system.

C. Leave each ground rod uncovered from the rod clamp to the pole until the Engineer authorizes backfilling. Do not leave holes exposed that will endanger the public.

D. Alternative ground rod installation locations and arrangements shall be approved by the Engineer on a case by case basis.

E. Sufficiently tighten offset downlead wires to make a secure assembly of uniform appearance. Maintain evenly spaced distance between the offset downlead wire and the adjacent phase conductors.

3.11 GUYS

A. Provide guys at all points of unbalanced strain in conductor and structures at corners, junctions and deadends as shown on the Contract Drawings. Attach guys to poles at the load centers.

B. Provide span guys at all locations where down guys cannot be used, at all unbalanced loads on crossarms, and use stub poles where required to obtain proper guying clearance requirements. Do not install any guy in violation with NESC requirements.

C. Install each guy centered on the pole without pulling to either side or causing an unequal strain on guy hooks, clamps, or sections of the guy and hardware. Neatly sever or cut all guy tails.

D. Unless specified elsewhere, install down guys with a one-to-one (45 degree) lead-to-height ratio.

E. All guys shall be bonded to the pole grounding system unless otherwise directed by the Engineer. Grounding jumpers shall be of minimum conductivity equivalent to the pole ground wire. Grounding connectors to the guy and the system ground wire shall be compression type suitable for dissimilar metals.

F. Guys shall be placed before the conductors are strung. Insure proper adjustment of guys when stringing operations are being performed so that loading on structures will be balanced.

G. Unless specified otherwise, guy attachment, hooks or plates shall only have one guy attached.

H. Guy primary framing and secondary framing separately.

3.12 ANCHORS

A. Anchors shall be installed according to Manufacturer's instructions.

B. Locate anchors as far as practical from street crossings, driveways, crosswalks, and foot paths.

C. Install all anchor rods in line with the strain and the guy slope. Do not install anchor rods vertically and then bend or trench them into position. Leave no more than 6 inches of the rod exposed above ground. In cultivated fields, or disturbed soils where the rod might become covered, leave no more than 12 inches of the rod exposed above ground. In no case shall the eye of the rod be covered by soil.

D. On expanding anchors or rock anchors use an auger that will excavate a hole just large enough to accommodate the unexpanded anchor, such that, upon installation and expansion of the anchors the maximum holding capacity can be obtained. Do not use a large auger such as the pole auger.

E. The backfill for the anchor hole shall be thoroughly tamped with suitable soil the full length of the anchor hole.

F. Anchors shall be installed to sufficient depth and with sufficient torque such that each installation shall hold a total guy load specified on the framing plate detail.

G. Where power installed screw anchors are specified they shall be installed using a pre-determined value of torque which gives a positive indication of the holding capacity required. Install additional extension rods as necessary to obtain the required holding value for he depth installed. Keep records of the installing torque for each anchor and make available to Engineer upon request.

In no case shall the installing torque be less than 1500 pounds or three (3) shear pins.

H. For power installed screw anchors, a double helix anchor shall be installed at a depth no greater than 14 feet. If the required torque is not achieved, the anchor shall be removed and a double-helix square shaft or other multi-helix square shaft anchor shall be installed.

I. If difficulty is encountered in installing anchors, the Engineer shall be contacted to recommend additional installation methods.

3.13 HARDWARE AND BOLTS

A. Securely tighten all hardware.

B. Provide a washer at each point where a bolt head or nut bears on the surface of a pole or crossarm.

C. Provide a locknut with each nut, eyenut, or other fastener on all bolts or threaded hardware.

D. Carefully select bolts for proper length. Bolts shall extend at least ½ inch and not more than two (2) inches beyond nuts or locknuts. Eyebolts shall be in line with the strain at all deadends, and shall bisect the line angle and at all angles made that are not deadends. All bolts shall be in a level plane to the hardware attached.

E. Do not cut off bolts that are too long – replace them with proper length bolts.

F. All connections shall be bearing type connections. Bolt length shall provide for nuts, locknuts, and washer.

G. High strength bolts and their installation and bolting tools and equipment shall be in accordance with the structure manufacturer's recommendations and the "Specifications for Structural Joints Using ASTM A325 or A490 Bolts" including the commentary given therein, as approved by the Research Council on Riveted and Bolted Structural Joints of the Engineering Foundation and endorsed by AISC, except as otherwise modified or supplemented herein. Bolt length shall be selected in accordance with the Research Council specification. The Research Council specification is dated August 14, 1980. All methods, tools, and equipment shall be subject to the acceptance of the Engineer.

3.14 SWITCHES

A. Use proper size compression spades for terminal pads.

B. Adjust switches to Manufacturer recommendations. Switch operation shall be subject to inspection prior to energizing.

C. On pipe operated switches the set screws shall not be punched in until the switch is inspected.

D. Provide two connections to ground on metal support frames.

3.15 MISCELLANEOUS

A. Grounding Platform Installations:

1. For grounding platform installations at overhead line switches, install an area of 4" deep crushed aggregate extending a minimum of 1' beyond the edges of the grounding platform. Grading and aggregate placement shall ensure proper drainage and keep adjoining soil from washing into the aggregate.

3.16 PHASING OF CONDUCTORS

A. Verify phasing, whether indicated or not, by site review of each source connection at substation. Final phase rotation and placement is the responsibility of the Contractor.

3.17 REMOVALS

A. Keep careful and accurate records of all materials removed or reused as specified.

B. When backfilling holes at pole removal locations do not dig holes in the landscape to obtain backfill. Obtain backfill dirt by scooping or scraping within the designated right-of-way or by fill dirt obtained locally. Do not dig seeded areas within highway or public rights-of-way. Do not place foreign objects in backfill.

C. Reuse only those materials as specified or as indicated that are equivalent in size, rating, capacity and other requirements of new materials and not damaged or deteriorated. Reuse of any other materials shall have prior approval by the Engineer. Upon this approval careful and accurate records shall be kept and submitted to the Engineer itemizing the particular materials reused and the location of their use.

D. Immediately remove from the job site any materials that are removed from existing assemblies.

3.18 NAMEPLATES AND LABELING

A. All utility, electrical, and light poles shall be labeled as shown on the plan.

B. Pole tags shall be installed per manufacturer's recommendations at approximately 5 feet above finished grade.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement should be made as per-each overhead line.

4.02 PAYMENT

A. Payment for poles, insulators and associated hardware shall be per each pole assembly.

B. Payment for conductors shall be per each size and type.

C. Payment shall include furnishing, installing, transporting, labor, incidental materials, grounding, testing, nameplates/labeling, etc. for a complete installation.

END OF SECTION

PART 1 - GENERAL

1.01 SCOPE

A. Overhead electric system construction

B. Materials and Equipment

1.02 RELATED SPECIFICATIONS

A. Section 16020: Electrical Tests

B. Section 16450: Grounding and Bonding

C. Section 16371 – Overhead Line Construction

1.03 CODES AND STANDARDS

A. All Work shall conform to these Specifications and to the applicable requirements of the latest edition of the following codes, regulations and standards.

1. ANSI - American National Standards Institute
2. IEEE - Institute of Electrical and Electronic Engineers
3. NEC - Latest Edition of National Electric Code
4. OSHA - Occupational Safety and Health Administration.
5. UL - Underwriters' Laboratories, Inc.
6. Requirements of the applicable Utility companies.
7. Any law, regulation, or decision of the government agency or Authority Having Jurisdiction (AHJ) over this work shall apply.

B. Published Specifications, standards, tests, or recommended methods of trade, industry, or governmental organizations apply to work in this section.

C. All components shall be designed, manufactured and tested in accordance with the latest applicable standards of ANSI, NEMA, NESC and UL.

1.04 SUBMITTALS

A. Shop drawings shall be submitted for approval.

B. Final Drawings, Manuals, and Test Reports shall be provided prior to shipment.

1.05 QUALITY ASSURANCE

A. All materials, equipment and appurtenances used in construction of this project shall be new

and shall conform to those acceptable by standard publications used in line construction, unless otherwise specified herein.

B. Supply all equipment and accessories new and free from defects.

C. Supply all equipment and accessories in compliance with applicable standards and with all applicable national, state, and local codes.

D. All items of a given type shall be the products of the same Manufacturer.

PART 2 - PRODUCTS

2.01 ACCEPTABLE

A. All materials, equipment and appurtenances used in construction of this project shall be new, carry a minimum 1 year warranty for a period beginning with acceptance of the project by the Utility Owner, and shall conform to those as specified herein.

B. Manufacturer's names and catalog numbers are specified to establish the reliability, type, size, rating or capacity, design, or other features of the materials required. A closed specification is not intended, and duplicating items of other reputable manufacturers will be acceptable upon the Resident Project Representative's approval, unless otherwise specified.

2.02 WOOD PRODUCTS

A. Poles:

1. Douglas Fir or Southern Yellow Pine.
2. Treatment: Pentachlorophenol to pressure process full length HEAVY treatment as determined by assay method in accordance with RUS specification DT-5C, dated June 1987 as amended.
3. Poles shall be independently inspected and duplicate "Certificate of Inspection" shall be furnished to the Engineer.
4. POLES SHALL BE FIELD DRILLED

B. Crossarms and Timbers for Wood Pole Structures:

1. All wood crossarms shall be treated with pentachlorophenol with minimum retention of AWPA standard A5 Section 5 in accordance with RUS Specification DT-5B, dated January 1982.
2. Material and grade: All crossarms furnished under this specification shall be free of brashy wood, decay, and insect holes larger than 3/32 of an inch, shall meet additional requirements as shown on specific drawings, and shall be made of the following:
   a. Douglas-fir - conforming to the applicable crossarm provisions of paragraphs 170 and 170a or the applicable transmission arm provisions of paragraphs 169 and 169a of the 1991 Standard Grading Rules for West Coast Lumber No. 17. All references to Douglas-fir shall be that of coastal origin.
   b. Southern Yellow Pine - conforming to the provisions of Dense Industrial Crossarm 65, as

described in paragraph 31.2 in Southern Pine Inspection Bureau 1991 Special Product Rules for Southern Pine.

c. Laminated wood crossarms shall conform to ANSI 05.2-1983. Laminated arms shall have at least the same load carrying capacity as the solid sawn arm it replaces. The load carrying capacity of the laminated arms shall be determined by one of the procedures outlined in ANSI 05.2.

3. Knots - Only sound, firm and tight knots are allowed if well spaced. Slightly decayed knots are permitted, except on the top face, provided the decay extends no more than 3/4 inch into the knot and if the cavities will drain water when the arm is installed, if well spaced. Well spaced knots means that the sum of the sizes of all knots in any 6 inch of length of a piece must not exceed twice the size of the largest knot permitted. More than one knot of maximum permissible size must not be in the same 6 inch of length. Slightly decayed, firm or sound "Pin knots" (3/8 inch or less) are not considered in size, spacing or zone consideration.

4. Supplementary Limitations on Knots in Crossarms :

a. Knot clusters are prohibited unless the entire cluster, measured on the worst face is equal or less than the round knot allowed at the specific location.

b. Spike knots are prohibited in deadend (DE) arms. Any spike knot across the top face are limited to the equivalent displacement of a knot 3/8 inch deep on one face and the maximum round knots for its particular location on the worst face with a maximum width of 1 inch measured at the midpoint of the spiked section. Elsewhere across the bottom or side faces, spike knots shall not exceed 1/2 the equivalent displacement of a round knot permitted at that location provided that the depth of the knot on the worst face shall not exceed the maximum round knot allowed at that location.

c. Loose knots and knot holes shall drain water when the arm is normally installed. In the center section, upper half, they shall not be greater than 1/2 the dimensions of round knots. Elsewhere, they shall not be greater than the round knot dimension. They are prohibited in DE arms.

d. All knots except those "spike" knots intersecting a corner are to be measured on the least diameter of the knot.

e. A knot shall be considered to occupy a specific zone or section if the center of the knot (i.e., pith of knot) is within the zone or on the zone's boundary.

f. If a round or oval knot appears on two faces and is in two zones, each face shall be judged independently. When this does occur, average the least dimension showing on both faces. In Free of Heart Center (FOHC) arms, if a knot occurs on only one face, it is allowed to be 25 percent larger than its stated size.

g. Knot spacing: Two or more knots opposite each other on any face are limited by a sum not to exceed the size of a maximum single knot permitted for the location. On all four faces, all knots shall be well spaced.

h. Knots, a maximum of 5/8 inch in diameter may intersect pin holes in the center section. One inch diameter knots may intersect pin hole elsewhere.

5. Miscellaneous Characteristics, Features and Requirements :

a. Pitch and Bark Pockets: For distribution crossarms, on the top face, pockets are limited to 4 medium pockets in 8 foot arms and not more than 5 in 10 foot arms. Elsewhere a maximum of 6 medium pockets in 8 foot arms and 8 in 10 foot arms shall be permitted. Equivalent smaller pockets are permissible. An occasional large pocket is permissible.

b. Shakes: Prohibited

c. Checks: Prior to treatment on properly seasoned arms, single face checks shall not exceed an average penetration of 1/4 the depth from any face and are limited to 10 inches long on the top face, and 1/3 the arm length on the other faces. Checks shall not be repeated in the same line of grain in adjacent pin holes. The sum of the average depths of checks occurring in the same plane on opposite faces shall be limited to 1/4 the face depth.

d. Compression wood is prohibited on any face. It is permitted if wholly enclosed in the arm, more than 6 annual rings from the surface and not over 3/8 inch in width.

e. Insect holes larger than 3/32 inch are prohibited. Pin holes (i.e., not over 1/16 inch diameter) are allowed if scattered and not exceeding 10 percent of the arm girth.

f. Wane is allowed on one edge, limited to approximately 1 inch, measured across the corner. Outside of the top center section, an aggregate length not to exceed 2 feet may have wane up to 1-1/2 inches on an occasional piece on one or both edges. Bark is to be removed.

g. Prior to preservative treatment, crook, bow, or twist shall not exceed 1/2 inch in 8 foot arms and 5/8 inch in 10 foot arms.

6. MANUFACTURE

a. All dimensions and tolerances shall conform to those shown on the drawings in this bulletin or supplied with the order. Cross-sectional dimensions shall be measured and judged at about 1/4 the arm length, except when the defects of "skip dressing" or "machine bite or offset" are involved. Drawings supplied shall not exceed minimum dimensions and tolerances shown on the drawings in this specification.

b. The lamination techniques shall be as defined in ANSI 05.2-1983.

c. Pin and bolt holes: Holes shall be smoothly bored without undue splintering where bits break through the surface. The center of any hole shall be within 1/8 inch of the center-line locations on the face in which it appears. The holes shall be perpendicular to the starting and finishing faces.

d. Shape: The shape of the arms at any cross section except for permissible wane shall be as shown on the respective drawings. The two top edges may be chamfered or Distribution for Steel Pole Structures:

2.03 INSULATORS

A. Distribution:

1. Wet-Process Porcelain insulators are to be used and shall comply with the following:

a. ANSI C29.5 - Low and medium voltage

b. ANSI C29.6 - High voltage pin type

c. ANSI C29.7- High voltage line – post type

d. ANSI C29.2 - Suspension/Strain

e. ANSI C29.4 - Strain/Brace

2.04 CONDUCTORS AND APPURTENANCES

A. All single conductors shall be Aluminum Conductor Steel Reinforced (ACSR) and sized as specified on contract drawings.

B. Aluminum alloy 1350-H-19 wires, concentrically stranded about a steel core.

C. ACSR bare conductor meets or exceeds the following ASTM specifications:

1. B-230 Aluminum Wire, 1350-H19 for Electrical Purposes
2. B-231 Aluminum Conductors, Concentric-Lay-Stranded
3. B-232 Aluminum Conductors, Concentric-Lay-Stranded, Coated Steel Reinforced (ACSR)
4. B-341 Aluminum-Coated Steel Core Wire for Aluminum Conductors, Steel Reinforced (ACSR/AZ)
5. B-502 Aluminum-Coated Steel Core Wire for Aluminum Conductors, Steel Reinforced (ACSR/AW)
6. B-498 Zinc-Coated Steel Core Wire for Aluminum Conductors, Steel Reinforced (ACSR/AZ)
7. B-500 Zinc Coated and Aluminum Coated Stranded Steel Core for Aluminum Conductors, Steel Reinforced (ACSR)

D. Triplex, XLP service conductor

E. Duplex, XLP service conductor

F. Miscellaneous Conductors:

1. Miscellaneous sizes and types as required for jumpers, connections, ties, etc. and handling, holding, tying, re-tying, sagging, etc.

2.05 Appurtenances:

A. Splices: ACSR

1. All 1-piece compression type (automatics)

B. Connectors:

1. All main line connections of ACSR, use compression connections as approved.
2. Miscellaneous sizes and types as required.

C. Stirrup – AMP shoot on type 600479 or as approved.

D. Clamp, Suspension, 3/8" Extra High Strength Steel: Anderson MS-46N

E. Pole name plates:

1. Pole name plates shall be painted aluminum with embossed letters. Background paint shall be white and the embossed lettering shall be black unless otherwise approved by the ENGINEER.
2. Aluminum thickness shall be at least 0.016".
3. Lettering shall be approximately 1" tall on one horizontal line.

2.06 POLE LINE HARDWARE

A. All hardware shall be hot-dip galvanized.

B. Locknuts type MF

C. Combination porcelain cutout and surge arrester

1. Designed with a solid core, bird proof, one piece porcelain frame with uniform shed configuration. Sulfur cemented studs provide high strength connections.
2. Fuseholder
   a. Interchangeability between manufactures is required.
   b. Constructed of an epoxy impregnated glass filament wound tube over an arc-quenching inner liner material.
   c. A large bronze cast pull ring for ease of installation and re-fusing. The bronze trunnion, with lifting ring having both front and side accessibility, with silver plated for minimum contact resistance.
   d. A grooved flipper assembly to control link tension, assuring low fault current interruption and preventing link breakage on "close-in."
   e. The cast bronze lower hinge assembly with deep pockets for the trunnion to pivot to minimize accidental fuse removal.
   f. Lower contact assembly with stainless steel backup springs and silver-to-silver contacts to minimize contact resistance.
   g. Contacts designed to carry 300 A continuous. Silver-to-silver top contacts are again used to minimize contact resistance.

2.07 GUYS AND ANCHORS

A. Guys:

1. Guy Strand: 9.525mm (3/8 inch) extra high strength steel, 7 strand class A galvanized.
2. Guy bonding clamps for anchor rod eyes, malleable iron with hot-dip galvanized steel bolt,

sized to rod eye type and guy strand.

3. Grounding jumpers No. 6 AWG solid soft drawn copper using suitable compression connectors.
4. Guy deadends – Preformed type rated at same breaking strength as guy strand.
5. Guy attachments at the pole should be mounted to the back of deadend assemblies or at their own separate attachment heights, and should be able to withstand loads up to 66.73kN (15,000 lbs.) per guy.
6. Guy Marker plastic PVC material 2.44m (8 ft.) yellow with spiral grip.
7. Guy Insulator – a minimum basic impulse insulation level (BIL) of 300 kV be maintained on all distribution pole tops to mitigate the possibility of lightning flashovers. The above objective can be achieved with the installation of guy strain insulators, when needed, as indicated contract drawings. Guys still need to be grounded by bonding them to one another and to the system neutral below the guy strain insulator.

B. Anchors:

1. Power installed Power Shaft action 254mm (10") double helix with 38.1mm x 2.133m (1½" X 7') Extension, and twineye eyebolt assembly, Rated strength after installation 30000lb.
2. Expansion or Power installed type rated 8000lb per RUS.

2.08 GROUNDS

A. Pole ground wires shall be No. 4 AWG solid soft drawn copper, unless otherwise noted on Contract Drawings.

B. Solid soft drawn copper for grounding jumpers, same size as pole grounds.

C. All connections for pole grounds shall be compression type

D. Ground rods copper clad 1.6cm x 2.4m (5/8" x 8'-0")

E. Ground rod clamps, hex head set screw,

PART 3 – EXECUTION (NOT USED)

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement should be made as per-each overhead line.

4.02 PAYMENT

A. The cost of complying with each section of this Specification is included in other bid items.

END OF SECTION

PART 1 - GENERAL

1.01 SCOPE

A. Work under this Section consists of Contractor furnished labor, materials and equipment necessary and incidental to provide electric service entrance and outdoor metal-enclosed switchgear and pad mounted distribution switches at the locations indicated on the Contract Drawings and as specified by the Engineer. The Contractor shall coordinate work of this Section with the other sections of this Specification.

1.02 RELATED SPECIFICATIONS

A. The Contractor shall coordinate work of this Section with all other Sections of the Specifications and the Contract Drawings. The following Sections contain requirements that relate to this Section:

1. Section 16010 - Basic Electrical Requirements
2. Section 16020 – Electrical Tests
3. Section 16025 – Electrical Codes
4. Section 16195 – Electrical Identification
5. Section 16450 – Grounding and Bonding
6. Section 16112 – Underground Conduit
7. Norfolk Southern Standard Specifications for Materials and Construction, Sections SC-1 to SC-25 (structural concrete) & UC-1 to UC-9 (underground conduit).

B. The service shall be installed per requirements of Electric utility. Approval of the Electric utility shall be obtained prior to energizing the service.

C. Types of equipment in this section include the following:

1. Pad-mounted distribution switches, including incoming switch and branch switches.

1.03 CODES AND STANDARDS

A. The Contractor shall comply with provisions of all local, state and federal codes, specifications, standards, and recommended practices, except as otherwise indicated, and in particular of the latest edition and addenda thereto of :

1. ANSI - American National Standards Institute
2. IEEE – Institute of Electrical and Electronic Engineers
3. NFPA - National Fire Protection Association
4. NEMA – National Electrical Manufacturers Association
5. NEC - National Electrical Code
6. 6. UL - Underwriters Laboratories, Inc.

1.04 SUBMITTALS – FOR REVIEW/APPROVAL

A. General: Submit the following in accordance with Special Conditions and Requirements of Contract and Specification Section 16010.

B. Product Data: Submit manufacturer's data on service-entrance equipment and accessories.

C. Submittal shall include:

1. Master drawing index
2. Front view elevation, floor plan, and top view showing dimensions and arrangements
3. Single Line
4. Nameplate Schedule
5. Conduit entry/exit locations
6. Assembly ratings including:
    a. Short-circuit rating
    b. Voltage
    c. Continuous current
7. Major component ratings including:
    a. Voltage
    b. Continuous current
    c. Interrupting ratings
8. Cable Termination sizes
9. Certified test reports of similar manufactured units showing fault-closing capability and load-interrupting capability of switches and complete pad-mounted gear assembly based on maximum design voltage.

1.05 SUBMITTALS FOR CLOSEOUT

A. Certified Drawings: Vendor to provide 6 sets of certified drawings: 4 sets to be sent to Construction Manager, 1 set to consulting engineer and 1 set with equipment.

B. Certified information required.

1. Items from 1.04 B. 3. (above)
2. Spare parts list and recommended spare parts.
3. Instructions for installation, operation and maintenance. Combine instructions for all electrical equipment, supplied by Vendor, into bound volumes.
4. Equipment names, per drawings that are covered by the manual.
5. Certified production test reports

1.06 DELIVERY, STORAGE AND HANDLING

A. Owner will establish delivery dates as items are released for engineering.

B. Vendor shall notify Owner's Representative two weeks prior to shipment to schedule in-plant inspection and checkout.

C. Bid "per specifications" with exceptions. A bid which rewrites this Specification or lists equipment being proposed is not acceptable. Vendor is encouraged to submit alternatives in addition to the required primary proposal.

D. Quote firm price and delivery, freight included, FOB job site. In addition, if shipment tracing and claim filing is available from Vendor, he is encouraged to quote FOB factory with freight allowed to job site.

E. After the order is placed, changes, additions and deletions to the order shall be made at the quoted multipliers with the price lists used at the time of quoting. These price lists shall be identified in the Vendor's proposal.

F. Quote as line items, field assistance during installation and start-up as well as training Owner's personnel.

G. Test reports will be required. Itemize the change in price, if any, for these tests.

1.07 QUALITY ASSURANCE

A. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."

B. NEMA Compliance: Comply with applicable requirements of NEMA standards pertaining to switches, fuses and electrical enclosures.

C. UL Compliance and Labeling: Comply with applicable requirements of UL standards pertaining to electrical labels and markers. Provide products and components listed and labeled by UL.

D. Installer's Qualifications: Firm with at least 5 years of successful installation experience with projects utilizing equipment similar to that required for this project.

E. Provide service-entrance equipment and accessories which are UL-listed and labeled, and marked, "SUITABLE FOR USE AS SERVICE EQUIPMENT."

1.08 GUARANTEE

A. Vendor shall guarantee his equipment against faulty material and workmanship for 18 months after shipment or 12 months from time of operating acceptance by Owner, whichever comes first.

B. Upon notice, the Vendor shall repair or replace in a reasonable period of time, any of his equipment which is faulty.

1.09 Operation and Maintenance Manuals

A. Ten (10) copies of the equipment Operation and Maintenance manuals shall be provided.

B. Operation and Maintenance manuals shall include the following information:

1. Instruction books and/or leaflets
2. Recommended renewal parts list
3. Drawings and information required by section 1.05.

1.10 JOB CONDITIONS

A. Coordinate with other work, as necessary, to interface with the Electric utility for service entrance and components.

B. Coordinate the size and location of concrete equipment pads. Cast anchor bolt inserts into pad. Concrete, reinforcement, and formwork requirements are specified in Norfolk Southern's Standard Specifications.

PART 2 - PRODUCTS

2.01 CONSTRUCTION

A. General: Provide pad-mounted distribution switches and accessories; of types, sizes, rating and electrical characteristics indicated, which comply with manufacturer's standard materials, design and construction in accordance with published product information, and as required for complete installation; and as herein specified. Component ratings shall be as follows, and also as shown on the drawings:

1. System Voltage: 3 Phase
2. Bus Continuous Amperes; 600A
3. Short Circuit Interrupting Rating: 25,000A RMS Symmetrical
4. Symmetrical at rated nominal voltage.
5. Duty-Cycle fault closing Amps 40,000 RMS Asymmetrical
6. Source Switch 600 amp, 3 phase
7. Load Switch Rating: 600 Amp, SML-20 fuses, 1 phase switching
8. All components included with the switches shall meet or exceed the short circuit rating of the switch.

B. The pad-mounted switches shall be complemented by UL listing. Construction of switchgear shall conform to specification listed in S&C Bulletin 665-451.

C. The pad-mounted gear shall be in accordance with the applicable plans, drawings and one-line diagrams and conform to these specifications.

D. Assembly: The outdoor pad-mounted gear shall consist of a single self-supporting enclosure, containing three-phase, group operated interrupter switches and three-phase sets of single-pole fuses with the necessary accessory components, all completely factory assembled and operationally checked.

E. Coordination: To ensure a completely coordinated design, the pad-mounted gear shall be integrally designed and produced by the manufacturer of the basic switching equipment.

F. Enclosure design: To ensure a completely coordinated design, the pad-mounted gear shall be constructed in accordance with the minimum construction specifications of the fuse and/or switch manufacturer to provide adequate electrical clearances and adequate space for fuse handling. In establishing the requirements for the enclosure design, consideration shall be given to all relevant factors such as controlled access and tamper resistance.

G. Switch, insulators, bushings and bushing wells shall have the following characteristics:

1. Operating experience of least 15 years under similar conditions.
2. Ablative action to ensure non-tracking properties.
3. Adequate leakage distance established by test per IEC standard 60507
4. Adequate strength for short-circuit stress established by test.
5. Conformance with applicable ANSI standards.
6. Any surface damage to insulating components during installation, maintenance or power arcing shall expose material of the same composition and properties so that insulating components with minor surface damage need not be replaced.

H. High-Voltage Bus:

1. Bus and interconnections shall consist of bare aluminum bar of 56% IACS conductivity with an oxide-inhibiting agent at all bus joints.
2. Bus and interconnections shall withstand the stresses associated with short circuits up through the maximum rated of the pad-mounted gear, including proper allowance for transient conditions.
3. Bolted aluminum-to-aluminum connections shall be made with a suitable number of non-corrosive bolts and with two Belleville spring washers per bolt

I. Ground-Connection Pads:

1. A ground connection pad shall be provided in each termination compartment of the pad-mounted gear.
2. The ground connection pad shall be constructed of ¼" thick, galvanized or stainless steel and have a NEMA 2-hole pattern for ground connections. The pad shall be welded to the enclosure and shall have a short-circuit rating equal to that of the integrated assembly.
3. A full width copper grounding rod shall be provided in each cable terminating compartment.

J. Enclosure:

1. Enclosure shall be of unitized construction to maximize strength, minimize weight, and inhibit internal corrosion.
2. The basic material for the enclosure, roof and doors shall be 11 gauge, hot rolled, pickled-and-oiled steel sheet.
3. All structural joints and butt joints shall be welded, and external seams shall be ground flush and smooth. A welding process shall be employed that eliminates alkaline residues and

minimizes distortion and spatter.

4. To guard against unauthorized or inadvertent entry, enclosure construction shall not utilize any externally accessible hardware.
5. The base shall consist of continuous 90-degree flanges, turned inward and welded at the corners, for bolting to the concrete pad.
6. The door openings shall have 90-degree flanges, facing outward, that shall provide strength and rigidity as well as deep overlapping between doors and door openings to guard against water entry.
7. In consideration of tamper resistance, the enclosure shall conform to or exceed the requirements of ANSI/IEEE C57.12.28.
8. A heavy coat of insulating "no-drip" compound shall be applied to the inside surface of the roof to reduce condensation of moisture thereon.
9. Lifting tabs shall be removable. Sockets for the tab bolts shall be blind tapped. A protective, non-hygroscopic material shall be placed between the tabs and the enclosure to prevent scratching of the enclosure finish.

K. Barrier Assembly:

1. Insulating interphase and end barriers shall be provided in each switch and fuse compartment as required to achieve necessary insulation levels. This barrier system shall be constructed of fiberglass reinforced polyester.

L. Doors:

1. Doors shall be constructed of 11 gauge hot-rolled, pickled-and-oiled steel sheet.
2. Door edge flanges shall overlap with door opening flanges to create a mechanical maze that shall guard against water entry or insertion of foreign objects.
3. Doors shall have a minimum of three stainless steel hinges and hinge pins, secured in place.
4. One active and one passive door shall be provided in consideration of controlled access and tamper resistance, each door shall be equipped with a positive-action three-point auto-latch mechanism and padlock hasp.
5. Each door shall be provided with a stainless steel cover over the operating bolt, which shall be pad-lockable and incorporate a hood to protect the padlock.
6. Each door shall be independently secured and latched to the enclosure and shall not require a tool to open.
7. Doors providing access to fuses shall have provisions to store spare fuses.
8. Each door shall be provided with a stainless steel door holder located above the door opening.

M. Finish:

1. Full coverage joints and blind areas shall be achieved by processing enclosures independently of components such doors and roofs before assembly.
2. All exterior seams shall be sanded or ground smooth.

3. All surfaces shall undergo a chemical cleaning, phosphatizing and sealing process before any protective coatings are applied.
4. The finishing system shall be applied without sags or runs.
5. Unless otherwise specified, the color shall be Munsell No. 7GY3.29/1.5, dark green.

N. Basic components:

1. Interrupter Switches
   a. Switches shall have a three-time duty-cycle fault-closing rating equal to or exceeding the short circuit rating equal to or exceeding the short rating of the integrated pad-mounted gear assembly.
   b. Interrupter switches shall utilize a quick-make, quick-make mechanism installed by the switch manufacturer, integrally mounted on the switch frame.
   c. Switches shall be operated by means of an externally accessible switch-operating hub. The hub shall be located within a recesses stainless steel pocket mounted on the side of the pad-mounted enclosure. The hub pocket shall include a pad-lockable access cover. Labels to indicate switch positions shall be provided.
   d. Each switch shall be completely assembled and adjusted by the manufacturer on a rigid mounting frame.
   e. Switch shall be provided with contact blades and interrupters for circuit closing. Spring-loaded auxiliary blades shall not be permitted.
   f. Circuit interruption shall be accomplished by use of an interrupter which is positively and inherently sequenced with the blade position.
   g. Switches shall have a readily visible open gap in the open position to allow positive verification, and an open/close label shall be provided to give visual indication of switch position.
   h. Each switch shall be provided with a switch operating handle, secured to the inside of the switch-operating hub pocket and stored behind the switch-operating hub access cover.

O. Switch Compartments:

1. Switch terminals shall be equipped with 600 ampere rated bushings that include removable threaded studs to accommodate a choice of termination systems. Fuse terminals are equipped with 200 ampere rated bushing wells.
2. Viewing windows are provided within the termination compartments to allow visual verification of switch position and inspection of blown-fuse indicators on power fuses.

P. Fuse Compartment:

1. Fuse access panels shall have a mechanical interlock that guards against gaining access to the fuse before opening the load break connector at the fuse terminal.
2. The fuse shall be accessible only when de-energized and isolated, for full view removal with a shotgun stick.
3. Access to the compartment containing energized components when the fuses are being

changed shall be blocked by a latched GPO-3 panel.

4. Individual parking stands shall be provided for each fuse mounting to allow convenient installation of elbow accessories to accommodate grounding. A ground rod shall be installed across the full width of the fuse compartments for connecting of cable concentric neutrals.
5. To provide maximum service life and to prevent corrosion of moving parts, all latches and pivots in the fuse-handling mechanism shall be either painted steel, stainless steel, or zinc-plated.

Q. Labeling

1. Warning Signs: All external doors shall be provided with approved "WARNING – HIGH VOLTAGE – KEEP OUT" signs.

R. Nameplates, Ratings Labels & Connection Diagrams:

1. The outside of both the front and back shall be provided with nameplates indicating the manufacturer's name, catalog number, model number, and date of manufacture.
2. The inside of each door shall be provided with a ratings label indicating the following: voltage ratings; main bus continuous rating; short circuit rating; type of fuse and its ratings.
3. A three-line connection diagram showing interrupter switches, fuses and bus along with the manufacturer's model number shall be provided on the inside of both the front and rear doors, and on the inside of each switch-operating hub access cover.

S. Accessories: End fittings or holders, and fuse units or refill units for original installation, as well as spare fuse unit for each mounting, shall be furnished in accordance with the client's requirements when specified.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions under which service-entrance equipment and components are to be installed, and notify Engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until satisfactory conditions have been corrected in a manner acceptable for installation.

3.02 INSTALLATION OF MAIN SWITCHGEAR AND PADMOUNTED SWITCHES

A. Install equipment as indicated, in accordance with utility company requirements, equipment manufacturer's written instructions, and with recognized industry practices, to ensure that service-entrance equipment fulfills requirements. Comply with applicable installation requirements of NEC and NEMA standards.

B. Tighten electrical connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torque requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standard 486A. Use properly scaled torque indicating hand tool.

3.03 FIELD QUALITY CONTROL

A. Prior to energization of main switchgear and pad-mounted switches, check accessible connections for compliance to manufacturer's torque tightening specifications.

B. Prior to energization of equipment, check with ground resistance tester, phase-to-phase and phase-to-ground insulation resistance levels to ensure requirements are fulfilled.

C. Prior to energization, check circuitry for electrical continuity, and for short-circuits.

3.04 GROUNDING

A. Provide equipment grounding connections for main switchgear and pad-mounted switches as indicated. Tighten connections to comply with tightening torques specified in UL Std 486A to assure permanent and effective grounding.

3.05 ADJUSTING AND CLEANING

A. Adjust operating mechanisms for free mechanical movement.

B. Touch-up scratched or marred enclosure surfaces to match original finishes.

3.06 DEMONSTRATION

A. Upon completion of installation of equipment and electrical circuitry, energized circuitry and demonstrate capability and compliance with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and retest to demonstrate compliance.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement should be made as per-each pad mounted switch.

4.02 PAYMENT

A. Payment shall be per each pad mounted switch.

B. Payment shall include furnishing, installing, transporting, labor, incidental materials, grounding, testing, etc. for a complete installation.

END OF SECTION

PART 1 - GENERAL

1.01 SCOPE

A. The contractor shall furnish and install, where indicated, a free-standing, dead-front type low voltage distribution switchboard, utilizing group mounted circuit protective devices as specified herein, and as shown on the contract drawings.

1.02 RELATED SPECIFICATIONS

A. Section 16195 – Electrical Identification

1.03 CODES AND STANDARDS

A. Manufactured and tested according to:

1. NEC - National Electrical Code
2. IEEE - Institute of Electrical and Electronics Engineers
3. NEMA - National Electrical Manufacturer's Association
4. UL - Underwriters Laboratories, Inc.
5. ANSI - American National Standards Institute
6. NFPA – National Fire Protection Association

B. Design Criteria

1. Design ambient temperature 60°C.
2. Plant elevation as shown on contract drawings.
3. Seismic zone as shown on contract drawings.

1.04 SUBMITTALS -- FOR REVIEW/APPROVAL

A. The following information shall be submitted to the Engineer:

1. Master drawing index
2. Front view elevation
3. Floor plan
4. Top view
5. Single line
6. Nameplate schedule
7. Starter and component schedule
8. Conduit entry/exit locations
9. Assembly ratings including:

a. Short-circuit rating

b. Voltage

c. Continuous current

10. Major component ratings including:

a. Voltage

b. Continuous current

c. Interrupting ratings

11. Cable terminal sizes.

B. Submit six (6) copies of the above information.

1.05 SUBMITTALS -- FOR CLOSEOUT

A. The following information shall be submitted for record purposes:

1. Final as built drawings and information for items listed in section 1.04
2. Unit wiring diagrams
3. Certified production test reports
4. Installation information
5. Seismic certification and equipment anchorage details.

B. Submit six (6) copies of the above information.

C. Equipment names, per drawings that are covered by the manual.

1.06 DELIVERY, STORAGE AND HANDLING

A. Equipment shall be handled and stored in accordance with Manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

B. Equipment shall be packaged for outdoor storage.

1.07 GUARANTEE

A. Vendor shall guarantee his equipment against faulty material and workmanship for 18 months after shipment or 12 months from time of operating acceptance by OWNER, whichever comes first.

B. Upon notice, the Vendor shall repair or replace in a reasonable period of time, any of his equipment which is faulty.

1.08 OPERATION AND MAINTENANCE MANUALS

A. Ten (10) copies of the equipment Operation and Maintenance manuals shall be provided.

B. Operation and Maintenance manuals shall include the following information:

1. Instruction books and/or leaflets
2. Recommended renewal parts list
3. Drawings and information required by section 1.05.

PART 2 - PRODUCTS

2.01 RATINGS

A. The assembly shall be rated to withstand mechanical forces exerted during short-circuit conditions when connected directly to a power source having a minimum available fault current of 42,000 amperes symmetrical or as shown on the drawings, whichever is greater.

B. Voltage rating to be 480 Volts unless otherwise indicated on the Drawings.

2.02 CONSTRUCTION

A. Switchboard shall consist of the required number of vertical sections bolted together to form a rigid assembly. The sides and rear shall be covered with removable bolt-on covers. All edges of front covers or hinged front panels shall be formed. Provide adequate ventilation within the enclosure.

B. All sections of the switchboard shall be rear aligned with depth as shown on the drawings. All protective devices shall be group mounted. Devices shall be front removable and load connections front accessible enabling switchboard to be mounted against a wall.

C. The assembly shall be provided with adequate lifting means.

D. The switchboard shall be suitable for use as service entrance equipment and be labeled in accordance with UL requirements.

2.03 BUS

A. All bus bars shall be silver-plated copper. Main horizontal bus bars shall be mounted with all three phases arranged in the same vertical plane. Bus sizing shall be based on NEMA standard temperature rise criteria of 65 degrees C over a 60 degrees C ambient (outside the enclosure).

B. Provide a full capacity neutral bus where a neutral bus is indicated on the drawings.

C. A copper ground bus (minimum 1/4 x 2 inches) shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the switchboard.

D. All hardware used on conductors shall be high-tensile strength and zinc-plated. All bus joints shall be provided with conical spring-type washers.

2.04 WIRING/TERMINATIONS

A. Small wiring, necessary fuse blocks and terminal blocks within the switchboard shall be furnished as required. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer's wiring diagrams.

B. Mechanical-type terminals shall be provided for all line and load terminations suitable for copper or aluminum cable rated for 75 degrees C of the size as indicated on the drawings.

C. Lugs shall be provided in the incoming line section for connection of the main grounding conductor. Additional lugs for connection of other grounding conductors shall be provided as indicated on the drawings.

D. All control wire shall be type SIS, bundled and secured with nylon ties. Insulated locking spade terminals shall be provided for all control connections, except where saddle type terminals are provided integral to a device. All current transformer secondary leads shall first be connected to conveniently accessible short-circuit terminal blocks before connecting to any other device. All groups of control wires leaving the switchboard shall be provided with terminal blocks with suitable numbering strips. Provide wire markers at each end of all control wiring.

2.05 MAIN PROTECTIVE DEVICE

A. Protective devices shall be fixed switchboard class insulated case low-voltage power circuit breakers. Frame ratings shall be 800, 1600, 2000, 3200, 4000, 5000, or 6000 amperes. The 800, 1600, 2000 and 3200 ampere frame circuit breakers shall provided in the same physical frame size, while 4000, 5000, and 6000 ampere frame circuit breakers shall be provided in a second physical frame size. Both physical frame sizes shall have a common height and depth. All breakers shall be UL listed for application in their intended enclosures for 100% of their continuous ampere rating.

B. Breakers shall be manually operated.

C. All insulated case circuit breakers shall have a minimum symmetrical interrupting capacity of 65,000 amperes. To ensure a selective system, all circuit breakers shall have 30-cycle short-time withstand ratings equal to 18 times their frame ratings. Insulated case circuit breakers without an instantaneous trip element adjustment shall be equipped with a fixed internal instantaneous override set at that level.

D. All insulated case circuit breakers shall be constructed and tested in accordance with UL 1066. The circuit breakers shall carry a UL label.

E. Main insulated case circuit breakers shall be provided with trip units as specified in Paragraph 2.07.

F. To facilitate lifting, the insulated case circuit breaker shall have integral handles on the side of the breaker. The insulated case circuit breaker shall have a closing time of not more than 3 cycles. The primary contacts shall have an easily accessible wear indicator to indicate contact erosion.

G. The insulated case circuit breaker shall have three windows in the front cover to clearly indicate any electrical accessories that are mounted in the breaker. The accessory shall have a label that will indicate its function and voltage. The accessories shall be plug and lock type and UL listed

for easy field installation. They shall be modular in design and shall be common to all frame sizes and ratings.

H. The breaker control interface shall have color-coded visual indicators to indicate contact open or closed positions as well as mechanism charged and discharged positions. Manual control pushbuttons on the breaker face shall be provided for opening and closing the breaker. The power circuit breaker shall have a "Positive On" feature. The breaker flag will read "Closed" if the contacts are welded and the breaker is attempted to be tripped or opened.

I. The current sensors shall have a back cover window that will permit viewing the sensor rating on the back of the breaker. A rating plug will offer indication of the rating on the front of the trip unit.

J. A position indicator shall be located on the faceplate of the breaker. This indicator shall provide color indication of the breaker position in the cell. These positions shall be Connect (Red), Test (Yellow), and Disconnect (Green). The levering door shall be interlocked so that when the breaker is in the closed position, the breaker levering-in door shall not open.

K. Each insulated case circuit breaker shall offer sixty (60) front mounted dedicated secondary wiring points. Each wiring point shall have finger safe contacts, which will accommodate #10 AWG maximum field connections with ring tongue or spade terminals or bare wire.

2.06 MAIN BREAKER TRIP UNIT

A. Each low-voltage power circuit breaker and insulated case circuit breaker shall be equipped with a solid-state tripping system consisting of three current sensors, microprocessor-based trip device and flux-transfer shunt trip. Current sensors shall provide operation and communication function. The trip unit shall use microprocessor-based technology to provide the basic adjustable time-current protection functions. True rms sensing circuit protection shall be achieved by analyzing the secondary current signals received from the circuit breaker current sensors and initiating trip signals to the circuit breaker trip actuators when predetermined trip levels and time delay settings are reached. Interchangeable current sensors with their associated rating plug shall establish the continuous trip rating of each circuit breaker.

B. The trip unit shall have an information system that provides LEDs to indicate mode of trip following an automatic trip operation. The indication of the mode of trip shall be retained after an automatic trip. A reset button shall be provided to turn off the LED indication after an automatic trip.

C. The trip unit shall be provided with a display panel, including a representation of the time/current curve that will indicate the protection functions. The unit shall be continuously self-checking and provide a visual indication that the internal circuitry is being monitored and is fully operational.

D. The trip unit shall be provided with a making-current release circuit. The circuit shall be armed for approximately two cycles after breaker closing and shall operate for all peak fault levels above 25 times the ampere value of the rating plug.

E. Trip unit shall have selectable thermal memory for enhanced circuit protection.

F. Complete system selective coordination shall be provided by the addition of the following individually adjustable time/current curve shaping solid-state elements:

1. All circuit breakers shall have adjustments for long delay pickup and time.

2. Main circuit breakers shall have individual adjustments for short delay pickup and time, and include I2t settings.
3. Main shall have an adjustable instantaneous pickup.
4. Main circuit breaker shall have individually adjustable ground fault current pickup and time, and include I2t settings or ground alarm only.

G. The trip unit shall have provisions for a single test kit to test each of the trip functions.

H. The trip unit shall provide zone interlocking for the short-time delay and ground fault delay trip functions for improved system coordination. The zone interlocking system shall restrain the tripping of an upstream breaker and allow the breaker closest to the fault to trip with no intentional time delay. In the event that the downstream breaker does not trip, the upstream breaker shall trip after a preset time delay.

I. The trip unit shall have an information system that utilizes battery backup LEDs to indicate mode of trip following an automatic trip operation. The indication of the mode of trip shall be retained after an automatic trip operation. The indication of the mode of trip shall be retained after an automatic trip. A test pushbutton shall energize a LED to indicate the battery status.

2.07 FEEDER PROTECTIVE DEVICES

A. Protective devices shall be molded case circuit breakers with inverse time and instantaneous tripping characteristics.

B. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position. A push-to-trip button on the front of the circuit breaker shall provide a local manual means to exercise the trip mechanism.

C. Circuit breakers shall have a minimum symmetrical interrupting capacity as indicated on the drawings.

D. Circuit breakers 400-ampere frame and below shall be thermal-magnetic trip units and inverse time-current characteristics.

E. Circuit breakers 600-ampere through 1200-ampere frame shall be microprocessor-based rms sensing trip units.

F. Ground fault protection shall be provided where indicated.

G. Where indicated provide UL listed circuit breakers for applications at 100% of their continuous ampere rating in their intended enclosure.

2.08 FEEDER BREAKER TRIP UNITS

A. Each molded case circuit breaker microprocessor-based tripping system shall consist of three (3) current sensors, a trip unit and a flux-transfer shunt trip. The trip unit shall use microprocessor-based technology to provide the adjustable time-current protection functions. True rms sensing circuit protection shall be achieved by analyzing the secondary current signals

received from the circuit breaker current sensors, and initiating trip signals to the circuit breaker trip actuators when predetermined trip levels and time-delay settings are reached.

B. An adjustable trip setting dial mounted on the front of the trip unit, or interchangeable ratings plugs shall establish the continuous trip ratings of each circuit breaker. Rating plugs shall be fixed or adjustable as indicated. Rating plugs shall be interlocked so they are not interchangeable between frames, and interlocked such that a breaker cannot be closed and latched with the rating plug removed.

C. System coordination shall be provided by the following microprocessor-based time-current curve shaping adjustments:

1. Adjustable long-time setting (set by adjusting the trip setting dial or rating plug)
2. Adjustable short-time setting and delay with selective curve shaping
3. Adjustable instantaneous setting

D. The microprocessor-based trip unit shall have both powered and unpowered thermal memory to provide protection against cumulative overheating should a number of overload conditions occur in quick succession.

E. When the adjustable instantaneous setting is omitted, the trip unit shall be provided with an instantaneous override.

F. Where internal ground fault protection is specified, adjustable settings shall not exceed 1200 amperes. Provide neutral ground fault sensor for four-wire loads.

2.09 MISCELLANEOUS DEVICES

A. Each section of the switchboard shall be provided with a space heater thermostatically controlled. Power for the space heaters shall be obtained from a separate source as indicated on the drawings. Supply voltage shall be 120 volts AC.

2.010 ENCLOSURES

A. Outdoor NEMA 3R Enclosure

1. Outdoor enclosure shall be non-walk-in and meet applicable NEMA 3R UL requirements.
2. Enclosure shall have sloping roof downward toward rear.
3. Outer sections shall be the same widths as indoor structures, except each end of the outdoor assembly shall have an end trim.
4. The enclosure shall be provided with bolt-on rear covers for each section.
5. Doors shall have provisions for padlocking
6. Ventilating openings shall be provided complete with replaceable fiber glass air filters.
7. Provide space heaters thermostatically controlled for each structure with adequate wattage to prevent the accumulation of moisture.

8. Power for space heaters, lights and receptacles shall be obtained from a source as indicated on the drawings. Supply voltage shall be 120 volts AC.

2.011 NAMEPLATES

A. Engraved nameplates, mounted on the face of the assembly, shall be furnished for all main and feeder circuits as indicated on the drawings. Nameplates shall be laminated plastic, black characters on white background. Characters shall be 3/16-inch high, minimum. Nameplates shall give item designation and circuit number as well as frame ampere size and appropriate trip rating. Furnish master nameplate giving switchboard designation, voltage ampere rating, short-circuit rating, manufacturer's name, general order number, and item number.

B. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer's wiring diagrams.

2.012 FINISH

A. All exterior and interior steel surfaces of the switchboard shall be properly cleaned and provided with a rust-inhibiting phosphatized coating. Color and finish of the switchboard shall be ANSI 61 light gray.

PART 3 - EXECUTION

3.01 FACTORY TESTING

A. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards.

1. The switchboard shall be completely assembled, wired, adjusted, and tested at the factory. After assembly, the complete switchboard will be tested for operation under simulated service conditions to ensure the accuracy of the wiring and the functioning of all equipment. The main circuits shall be given a dielectric test of 2200 volts for one (1) minute between live parts and ground, and between opposite polarities. The wiring and control circuits shall be given a dielectric test of 1500 volts for one (1) minute between live parts and ground

B. The Manufacturer shall provide three (3) certified copies of factory test reports.

3.02 INSTALLATION

A. The Contractor shall install all equipment per the Manufacturer's instructions, contract drawings and National Electrical Code.

B. The assembly shall be provided with adequate lifting means and shall be capable of being moved into installation position and bolted directly to Contractor- supplied floor sills to be set level in Contractor provided concrete pad per all manufacturer's recommendations. All necessary hardware to secure the assembly in place shall be provided by the Contractor.

3.03 MANUFACTURER'S CERTIFICATION

A. A certified test report of all standard production tests shall be available to the Engineer upon request.

3.04 FIELD ADJUSTMENTS

A. The Contractor shall perform field adjustments of the protective devices as required to place the equipment in final operating condition. The settings shall be in accordance with the approved short-circuit study, protective device evaluation study and protective device coordination study.

B. Necessary field settings of devices, adjustments and minor modifications to equipment to accomplish conformance with an approved short-circuit and protective device coordination study shall be carried out by the Contractor at no additional cost to the owner.

3.05 FIELD TESTING

A. Follow the minimum requirements as stipulated in the NETA testing procedure for this type of electrical equipment.

B. Generate a field report on tests performed, test values experienced, etc., and make available to Owner or Engineer upon request.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement should be made as per each low voltage switchboard.

4.02 PAYMENT

A. Payment shall be per each low voltage switchboard.

B. Payment shall include furnishing, installing, transporting, labor, incidental materials, grounding, testing, etc. for a complete installation.

END OF SECTION

PART 1 - GENERAL

1.01 SCOPE

A. Disconnect switches, fuses and enclosures.

1.02 RELATED SPECIFICATIONS

A. Not Applicable

1.03 CODES AND STANDARDS

A. ANSI - American National Standards Institute

B. IEEE - Institute of Electrical and Electronic Engineers

C. NEC - National Electric Code

D. OSHA - Occupational Safety and Health Administration.

E. UL - Underwriters' Laboratories, Inc.

1.04 SUBMITTALS

A. Submit product data under provisions of Section 16010.

B. Include outline drawings with dimensions, and equipment ratings for voltage, ampacity, horsepower, and short circuit.

PART 2 - PRODUCTS

2.01 DISCONNECT SWITCHES

A. Fusible Switch Assemblies: NEMA Type HD; quick-make, quick-break, load interrupter, enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position. Handle lockable in OFF position. Fuse Clips: designed to accommodate Class R cartridge type fuses.

B. Non-fusible Switch Assemblies: NEMA Type HD; quick-make, quick-break, load interrupter, enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position. Handle lockable in OFF position.

C. Enclosure: NEMA Type 1 Indoors, 3R outdoors, or as indicated on contract drawings.

D. Provide manufacturer’s equipment ground kit in all disconnect switches.

2.02 FUSES

A. Fuses 600 Amperes and Less: Dual element, time delay, 600 volt, UL Class RK 5. Interrupting Rating 200,000 rms amperes.

B. Fuses 601 Amperes and Larger: Time delay, 600 volt, UL Class L. Interrupting Rating: 200,000 rms amperes.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install disconnect switches where indicated on contract drawings.

B. Install disconnect switches plumb and square to the building structure in a clean, neat, and workmanlike manor.

C. Provide identification as specified in Section 16195.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement should be made as per each disconnect switch.

4.02 PAYMENT

A. Payment shall be per each disconnect switch.

B. Payment shall include furnishing, installing, transporting, labor, incidental materials, grounding, testing, etc. for a complete installation.

END OF SECTION

PART 1 - GENERAL

1.01 SCOPE

A. Furnish and install all materials necessary to ground new power distribution equipment, structures, and equipment to the existing grounding system as shown on the contract drawings and specified herein.

B. Refer to Contract Drawings for grounding equipment that has been provided by others.

C. Install electrically continuous conduit systems. Install separate dedicated grounding conductors in each conduit run, do not use conduit as only grounding means.

D. Extend the solid-ground neutral of each voltage system to the grounding bus bars included in each enclosure and piece of equipment, and assure that a complete common bolted, earth-based, utility coordinated ground is provided for proper fault protection, lightning dissipation, and other static dissipation.

E. Provide bonding of all structural steel members, equipment frames, etc. Bond structures together and to ground grid.

F. Solidly ground the secondary neutral point of all Distribution Transformers as detailed in this section.

1.02 RELATED SPECIFICATIONS

A. Section 16020 - Electrical Tests

B. Section 16111 - Conduits and Raceways

C. Section 16120 -Wire and Cable

1.03 CODES AND STANDARDS

A. NEC - National Electrical Code

B. IEEE - Institute of Electrical and Electronics Engineers

C. NEMA - National Electrical Manufacturer's Association

D. UL - Underwriters Laboratories, Inc.

E. ANSI - American National Standards Institute

F. IPCEA - Insulated Power Cable Engineers Association

G. NFPA – National Fire Protection Association

1.04 SUBMITTALS

A. Not Applicable

PART 2 - PRODUCTS

2.01 GROUND RODS

A. Provide 3/4 in. diameter x 10 ft. long ground rods and all associated fittings that are listed by UL and approved by the Engineer.

B. Provide 1 in. diameter x 10 ft. long ground rods with threaded ends and all associated fittings that are listed by UL and approved by the Engineer for installation near marine areas.

2.02 GROUND CONDUCTORS

A. Provide bare stranded copper conductors, as approved by the Engineer, where bare conductors are used.

B. Provide Type THW or THWN insulated copper conductors where ground conductors are installed in conduits or where insulated conductors are specified outside of conduits.

2.03 GROUND PLATES

A. Provide ground plates as indicated on the Drawings. Submit data sheets to Engineer for approval prior to purchasing.

2.04 GROUND CONNECTIONS

A. Use an approved Exothermic welding process for making all connections between bare copper ground conductors, ground rods, and structural steel. Refer to grounding details on Drawings for part numbers of fittings.

B. Grounding connections to equipment such as transformers, motors, etc., and above ground connections shall be by lug connectors approved by Engineer prior to use.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Furnish and install an equipment grounding conductor with all circuit conductors over 100 volts. Connect with approved connections and terminators to boxes, devices, equipment, etc., and to ground buses in switchgear, motor control centers, and panelboards. Size in accordance with the National Electrical Code except not smaller than No. 12 for power and lighting circuits and No. 14 for control circuits. Bond the conductor to the conduit, where entering and leaving the conduit.

B. Furnish and install grounding conductors that are green, painted green, or taped green where exposed in a panel, motor control center, outlet box, junction box, etc.

C. Ground all enclosures, junction boxes, terminal boxes, panelboards, etc., and all non current-carrying metals. Insure that locknuts cut through enameled or painted metal surfaces in enclosures. Use bonding jumpers with UL approved clamps to connect isolated and/or non-continuous enclosures and non current-carrying metals.

D. Secure conduit connections to sheet metal enclosures such as cabinets, panelboards, pull

boxes, junction or wireways with double locknuts so that ground continuity will be assured. Bond wire(s), properly sized and installed, shall be attached to all conduit entering and leaving the enclosure by means of UL listed ground connector clamps or ground-ready conduit bushings. Bond the enclosure to an equipment ground conductor sized for the largest conduit entering the enclosure or the highest circuit ampacity of the conductors entering the enclosure per Table 250-122 of the NEC.

E. Make all grounding connections to structural steel members above ground. Building steel shall not be used for equipment grounding.

F. All receptacles shall be bonded to the grounding system using a separate grounding conductor running back to the ground bus in the associated distribution panel.

G. Install a separate and additional ground conductor for all flexible conduit connections that do not contain an internal equipment grounding conductor to insure continuity of conduit grounding system. For flexible conduits on motors, insure that this ground conductor is run externally using approved fittings. All other runs may be internal.

H. Ground motor terminal boxes by the use of a manufacturer-supplied ground lug or by drilling and tapping a hole for a ground screw. Remove paint prior to making the connection.

I. Bond together and to the equipment ground bus, conduits entering switchboards and motor control centers with #4/0 AWG wire and UL approved ground clamps.

J. Bond all discontinuous equipment frames, structural members, sliding connections, metal piping, etc., using bonding jumpers sized and installed in accordance with the latest edition of NEC. Coordinate location of joints that must be jumpered, with structural drawings and Owner's Representative.

K. Ground lighting fixtures by the use of a Manufacturer supplied ground lug or pigtail, or by use of ground clips fastened to bare metal, which is free of paint and other coatings.

L. Bond all flexible and non-conductive connections using bonding jumpers of # 4 AWG wire.

M. Bond motor frames to equipment frames using bonding jumpers sized and installed in accordance with the latest edition of NEC.

N. Bury grounding grid conductors a minimum of 48 inches below top of finished grade. Provide backfill that is free of debris and rocks. Leave sufficient slack in these conductors to ease stress due to expansion, contraction, and settling. Prior to covering of connections, have connections inspected by Owner's Representative.

O. Connect the transformer's secondary neutral point to the transformer enclosure and to a ground conductor connected to a separate ground electrode driven for that specific transformer. The neutral shall be connected to ground only at the transformer. Size these ground conductors in accordance with the latest NEC.

P. Cable trays are to be grounded in the following manner: Cable tray is to have a #4/0 AWG bare stranded copper conductor routed throughout the entire tray length, at each level for multiple trays. This conductor shall be permanently bonded to the cable tray every 10'-0", and shall terminate at the service end on the ground bus of the equipment room or primary service equipment.

Q. All instrumentation and shielded cable will have only one end of shield bonded to ground at the

instrumentation panel in the electrical room. These shields and rack will in turn be bonded to the building ground in the equipment room.

3.02 TEST REQUIREMENTS

A. Test entire grounding system per requirements in Specification Section 16020: Electrical Tests.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement should be made as per each type of system.

4.02 PAYMENT

A. Payment for a grounding system shall be per each grounding system.

B. The cost of complying with each section of this Specification for the grounding of equipment, enclosures, boxes, etc. and non current-carrying metal components to a grounding system is included in other bid items.

END OF SECTION

PART 1 - GENERAL

1.01 SCOPE

A. Furnish and install dry type encapsulated transformers for all distribution transformers as required and as specified herein.

1.02 RELATED SPECIFICATIONS

A. Section 16020: Electrical Tests

B. Section 16470: Panelboards

C. Section 16450: Grounding and Bonding

1.03 CODES AND STANDARDS

A. ANSI - American National Standards Institute

B. IEEE - Institute of Electrical and Electronic Engineers

C. NEC - National Electric Code

D. OSHA - Occupational Safety and Health Administration.

E. UL - Underwriters' Laboratories, Inc.

1.04 SUBMITTALS -- FOR REVIEW/APPROVAL

A. The following information shall be submitted to the Engineer:

A. Outline dimensions and weights

B. Technical Certification Sheet

C. Transformer ratings including:

a. kVA Rating

b. Primary and Secondary Voltage

c. Taps

d. Design Impedance

e. Insulation Class and Temperature Rise

f. Sound Level

g. Wiring Diagrams

D. Product Data Sheets

B. Submit six (6) copies of the above information.

1.05 SUBMITTALS -- FOR CLOSEOUT

A. The following information shall be submitted for record purposes:

A. Final (as-built) drawings and information for items listed in section 1.04

B. Installation information

B. Submit six (6) copies of the above information.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

1.07 GUARANTEE

A. Contractor shall guarantee his equipment against faulty material and workmanship for 18 months after shipment or 12 months from time of operating acceptance by Purchaser, whichever comes first.

B. Upon notice, the Contractor shall repair or replace in a reasonable period of time, any of his equipment which is faulty.

1.08 OPERATION AND MAINTENANCE MANUALS

A. Ten (10) copies of the equipment Operation and Maintenance manuals shall be provided.

B. Operation and Maintenance manuals shall include the following information:

A. Instruction books and/or leaflets

B. Recommended renewal parts list

C. Drawings and information required by section 1.05.

PART 2 - PRODUCTS

2.01 RATINGS

A. KVA and voltage ratings shall be as shown on the drawings.

B. Transformers shall be designed for continuous operation at rated kVA, for 24 hours a day, 365 days a year operation, with normal life expectancy as defined in ANSI C57.96.

C. Transformer sound levels shall not exceed the following ANSI and NEMA levels for self-cooled ratings:

Transformer Size	Maximum Sound Level
0 to 9 kVA	40 dB
10 to 50 kVA	45 dB

51	to	150 kVA	50 dB

2.02 CONSTRUCTION

A. Insulation Systems

A. Transformer insulation system shall be 5 - 75 kVA, three-phase: 185 degrees C insulation system with 115 degree C rise, encapsulated design.

B. Required performance shall be obtained without exceeding the above indicated temperature rise in a 60 degrees C maximum ambient, and a 24 hour average ambient of 30 degrees C.

C. All insulation materials shall be flame-retardant and shall not support combustion as defined in ASTM Standard Test Method D635.

B. Core and Coil Assemblies

A. Transformer core shall be constructed with high-grade, non-aging, grain-oriented silicon steel with high magnetic permeability, and low hysteresis and eddy current losses. Maximum magnetic flux densities shall be substantially below the saturation point. The transformer core volume shall allow efficient transformer operation at 10% above the nominal tap voltage. The core laminations shall be tightly clamped and compressed. Coils shall be wound of electrical grade COPPER with continuous wound construction. Aluminum coils will NOT be accepted.

B. On three-phase units rated 75 kVA and below, the core and coil assembly shall be completely encapsulated in a proportioned mixture of resin and aggregate to provide a moisture-proof, shock-resistant seal. The core and coil encapsulation system shall minimize the sound level.

C. On three-phase units rated 15 kVA and above the core and coil assembly shall be impregnated with non-hydroscopic, thermosetting varnish and cured to reduce hot spots and seal out moisture. The assembly shall be installed on vibration-absorbing pads.

C. Taps

A. Three-phase transformers rated 15 through 75 kVA shall be provided with six 2-1/2% taps, two above and four below rated primary voltage.

B. All single-phase transformers, and three-phase transformers rated below 15 kVA and above 500 kVA, shall be provided with the manufacturer's standard tap configuration.

2.03 ENCLOSURE

A. The enclosure shall be made of heavy-gauge steel. All transformers shall be equipped with a wiring compartment suitable for conduit entry and large enough to allow convenient wiring. The maximum temperature of the enclosure shall not exceed 90 degrees C. The core of the transformer shall be grounded to the enclosure.

B. On three-phase units rated 75 kVA and below the enclosure construction shall be encapsulated, totally enclosed, non-ventilated, NEMA 12, with lifting eyes.

2.04 FINISH

A. Enclosures shall be finished with ANSI 61 color, weather-resistant enamel.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Mount transformers on vibration isolators and make all connections using flexible conduit.

B. For transformers designated to be mounted on elevated stands on the wall, use mounting racks and brackets approved by the manufacturer for such application. Mount transformers on vibration isolators and make all connections using flexible conduit.

C. Ground transformers in accordance with NEC requirements and Section 16450: "Grounding and Bonding".

3.02 FIELD TESTING

A. Measure primary and secondary voltages for proper tap settings.

3.03 FIELD ADJUSTMENTS

A. Adjust taps on each transformer to deliver appropriate secondary voltage.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement should be made as per each low voltage dry type transformer.

4.02 PAYMENT

A. Payment shall be per each low voltage dry type transformer.

B. Payment shall include furnishing, installing, transporting, labor, incidental materials, grounding, testing, etc. for a complete installation.

END OF SECTION

PART 1 - GENERAL

1.01 SCOPE

A. The contractor shall furnish and install all panelboards as specified and as shown on the contract drawings.

B. Panelboards shall include power panels, and lighting panels.

1.02 RELATED SPECIFICATIONS

A. Section 16195 - Electrical Identification

B. Section 16450 - Grounding and Bonding

1.03 CODES AND STANDARDS

A. NEC - National Electrical Code

B. IEEE - Institute of Electrical and Electronics Engineers

C. NEMA - National Electrical Manufacturer's Association

D. UL - Underwriters Laboratories, Inc.

E. ANSI - American National Standards Institute

F. NFPA – National Fire Protection Association

1.04 SUBMITTALS -- FOR REVIEW/APPROVAL

A. The following information shall be submitted to the Engineer:

1. Breaker layout drawing with dimensions indicated and nameplate designation
2. Component list
3. Conduit entry/exit locations
4. Assembly ratings including:
    a. Short-circuit rating
    b. Voltage
    c. Continuous current
5. Cable terminal sizes.

B. Submit six (6) copies of the above information.

1.05 SUBMITTALS -- FOR CLOSEOUT

A. The following information shall be submitted for record purposes:

1. Final (as-built) drawings and information for items listed in section 1.04
2. Installation information

B. Submit six (6) copies of the above information.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Equipment shall be handled and stored in accordance with Manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

1.07 GUARANTEE

A. Contractor shall guarantee his equipment against faulty material and workmanship for 18 months after shipment or 12 months from time of operating acceptance by owner, whichever comes first.

B. Upon notice, the contractor shall repair or replace in a reasonable period of time, any of his equipment which is faulty.

1.08 OPERATION AND MAINTENANCE MANUALS

A. Ten (10) copies of the equipment operation and maintenance manuals shall be provided.

B. Operation and maintenance manuals shall include the following information:

1. Instruction books and/or leaflets
2. Recommended renewal parts list
3. Drawings and information required by section 1.05.

PART 2 - PRODUCTS

2.01 RATINGS

A. Panelboards rated 240 VAC or less shall have short-circuit ratings as shown on the drawings or as herein scheduled, but not less than 10,000-amperes RMS symmetrical.

B. Panelboards rated 480 VAC shall have short-circuit ratings as shown on the drawings or as herein scheduled, but not less than 42,000-amperes RMS symmetrical.

C. Panelboards shall be labeled with a UL short-circuit rating. All panelboards and devices shall be fully rated. No series-rated equipment will be accepted.

2.02 CONSTRUCTION

A. Interiors shall be completely factory assembled devices. They shall be designed such that switching and protective devices can be replaced without disturbing adjacent units and without removing the main bus connectors.

B. Trims for power and convenience panelboards shall be supplied with a hinged door over all circuit breaker handles. Doors in panelboard trims shall not uncover any live parts. Doors shall have a semi flush cylinder lock and catch assembly. Doors over 48 inches in height shall have auxiliary fasteners.

C. Panelboard trims shall cover all live parts. Switching device handles shall be accessible.

D. Surface trims shall be same height and width as box. Flush trims shall overlap the box by 3/4 of an inch on all sides.

E. A directory card with a clear plastic cover shall be supplied and mounted on the inside of each door. Directory Card shall have a typed schedule describing all circuits.

F. All locks, if applicable, shall be keyed alike.

2.03 BUS

A. Main bus bars shall be copper, sized in accordance with UL standards to limit temperature rise on any current carrying part to a maximum of 65 degrees C above an ambient of 40 degrees C maximum.

B. A bolted ground bus shall be included in all panels.

C. Full-size (100%-rated) insulated neutral bars shall be included for panelboards shown with neutral. Bus bar taps for panels with single-pole branches shall be arranged for sequence phasing of the branch circuit devices. Neutral busing shall have a suitable lug for each outgoing feeder requiring a neutral connection.

2.04 PANELBOARD CIRCUIT BREAKERS

A. Bolt-in type, heavy-duty, quick-make, quick-break, single- and multi-pole circuit breakers of the types specified herein, shall be provided for each circuit with toggle handles that indicate when unit has tripped.

B. Circuit breakers shall be thermal magnetic type with common type handle for all multiple pole circuit breakers. Circuit breakers shall be minimum 100-ampere frame and through 100-ampere trip sizes shall take up the same pole spacing. Circuit breakers shall be UL listed as type SWD for lighting circuits and type HACR for HVAC equipment.

C. Circuit breaker handle locks shall be provided for all circuits that supply emergency lights and control system panels.

D. Circuit breakers shall have a minimum interrupting rating of 10,000-amperes symmetrical at 240/120 or 208/120-volts, and 42,000-amperes symmetrical at 480-volts.

2.05 ENCLOSURE

A. Enclosures shall be 20 inches wide and fabricated from galvanized steel. Provide minimum gutter space in accordance with the National Electric Code. Where feeder cables supplying the mains of a panel are carried through its box to supply other electrical equipment, the box shall be sized to

include the additional required wiring space. At least four interior mounting studs with adjustable nuts shall be provided.

B. Enclosures shall be provided with blank ends.

2.06 NAMEPLATES

A. Provide an engraved nameplate for each panel section.

2.07 FINISH

A. Surfaces of the trim assembly shall be properly cleaned, primed, and a finish coat of gray ANSI 61 paint applied.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Panels shall be mounted with top of panel at 6'-0" above floor.

B. Install as required and as recommended by Manufacturer.

C. Where the premises wiring system has branch circuits supplied from more than one nominal voltage system, each ungrounded conductor of a branch circuit where accessible, shall be identified by system. The means of identification shall be permitted to be by separate color coding, marking tape, tagging, or other approved means and shall be permanently posted at each branch-circuit panelboard or similar branch-circuit distribution equipment per NEC Article 210.5. The grounded conductor of a branch circuit shall be identified in accordance with NEC Article 200.6. The equipment grounding conductor shall be identified in accordance with NEC Article 250.119.

D. Ground panelboards in accordance with NEC requirements and Section 16450.

E. Contractor to furnish and install a permanent plaque located at each panelboard to identify the color code identification for ungrounded conductors.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement should be made as per each panelboard.

4.02 PAYMENT

A. Payment shall be per each panelboard.

B. Payment shall include furnishing, installing, transporting, labor, incidental materials, grounding, testing, etc. for a complete installation.

END OF SECTION

PART 1 - GENERAL

1.01 SCOPE

A. Enclosed molded case circuit breakers.

1.02 RELATED SPECIFICATIONS

A. Not Applicable

1.03 CODES AND STANDARDS

A. ANSI - American National Standards Institute

B. IEEE - Institute of Electrical and Electronic Engineers

C. NEC - National Electric Code

D. OSHA - Occupational Safety and Health Administration.

E. UL - Underwriters' Laboratories, Inc.

1.04 SUBMITTALS

A. Submit product data under provisions of Section 16010.

B. Include circuit breaker ratings, withstand ratings, frame size, time-current and let-through current curves, outline dimensions, and terminal lug sizes.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

PART 2 - PRODUCTS

2.01 CIRCUIT BREAKERS

A. Molded Case Circuit Breakers: Inverse time with integral thermal and instantaneous magnetic trip elements in each pole.

A. Electronic Trip Circuit Breaker: As scheduled on the drawings, electronic circuit breakers shall have, at a minimum, adjustments for long time trip and instantaneous trip. Provide integral ground fault sensing with adjustable ground fault trip where indicated on the drawings.

2.02 RATINGS

A. Ratings as shown on the Drawings.

2.03 ENCLOSURE

A. Enclosure: NEMA AB 1; Type 1.

B. Fabricate enclosure from steel.

C. Finish using manufacturer's standard gray enamel finish.

2.04 ACCESSORIES

A. Provide accessories as scheduled, to NEMA AB 1.

B. Handle Lock: Include provisions for padlocking where indicated. Provide lock-on devices where indicated on the drawings.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install enclosed circuit breakers where shown on Drawings, in accordance with manufacturer's instructions.

3.02 ADJUSTING

A. Adjust trip and time delay settings to values as recommended in coordination study provided by manufacturer or as instructed by the Architect/Engineer.

3.03 FIELD QUALITY CONTROL

A. Inspect visually and perform several mechanical ON-OFF operations on each circuit breaker.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement should be made as per each enclosed circuit breaker.

4.02 PAYMENT

A. Payment shall be per each enclosed circuit breaker.

B. Payment shall include furnishing, installing, transporting, labor, incidental materials, grounding, testing, etc. for a complete installation.

END OF SECTION

PART 1 - GENERAL

1.01 SCOPE

A. Manual motor starters, magnetic motor starters, combination magnetic motor starters and motor control centers.

1.02 RELATED SPECIFICATIONS

A. Section 16190 - Supporting Devices.

1.03 CODES AND STANDARDS

A. NEC - National Electrical Code

B. IEEE - Institute of Electrical and Electronics Engineers

C. NEMA - National Electrical Manufacturer's Association

D. UL - Underwriters Laboratories, Inc.

E. ANSI - American National Standards Institute

F. NFPA – National Fire Protection Association

1.04 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 16010.

B. Indicate on shop drawings, front and side views of motor control center enclosures with overall dimensions. Include conduit entrance locations and requirements; nameplate legends; size and number of bus bars per phase, neutral and ground; electrical characteristics including voltage, frame size and trip ratings, withstand ratings, and time-current curves of all equipment and components.

C. Provide product data on motor starters and combination motor starters, relays, pilot devices, and switching and overcurrent protective devices.

D. Submit manufacturers' instructions under provisions of Section 16010.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

B. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to motor control center components, enclosure, and finish.

1.06 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 16010.

B. Include spare parts data listing; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals.

1.07 COORDINATION WITH OTHER TRADES

A. Motors: In general, all electric motors required for this installation will be supplied with equipment, apparatus and/or appliances covered under other sections of the specifications.

B. For the sake of consistency and conformity of manufacturer, design and construction, all motors shall conform to the following description unless otherwise noted or required.

C. Motors 1/3 HP and smaller shall be wound for operation on single phase, 60 Hz. service unless otherwise noted.

D. Motors 1/2 HP and above shall be wound for operation on 3 phase, 60 Hz service unless otherwise noted.

E. Refer to drawings in each case in order to verify voltage characteristics required.

F. Equipment:

1. All building utility motors such as fans, pumps, overhead doors, etc., together with certain "controlling equipment" for same, except motor starters and related apparatus, will be furnished under other sections of the specifications and delivered to the building site unless specifically noted otherwise. The above mentioned "controlling equipment" pertains to electrical thermostats, electro-pneumatic and pneumatic-electric and detection devices, or any other device not purely electrically operating in nature.

2. The starters for these motors shall be furnished and installed by the Electrical Trade unless noted otherwise. (See Motor Schedule on Drawings).

3. The Electrical Contractor shall set and connect all specified starting equipment, install all power conduits and wiring and shall furnish and make all connections from starting equipment to motors as required to leave the apparatus in running condition.

G. Wiring Connections:

1. Furnish branch circuits for all motors to the starting equipment and then to the motors, complete with all control wiring for automatic and remote control where required or noted. Conduits to motors shall terminate in the conduit fittings on the motors, the final connection being made with flexible, liquid-tight conduit, seal-tight "UA", or as approved.

2. Provide all necessary labor and material to completely connect all electrical motors and controls (where required) in connection with the building utility equipment, including fans, pumps, overhead door operators, etc.

3. All conduits and wiring required for control work from the holding coil circuit of the starter, including the furnishing and installation of control devices such as auxiliary contacts, control relays, time delay relays, pilot lights, selector switches, alternators, etc., shall be provided and installed by other trades unless otherwise indicated.

H. Power Branch Circuits:

1. Wire sizes for branch circuits not specifically called for on Drawings or in Specifications shall be based on 125 percent of the full load current of the motor unless the voltage drop of motor branch circuits exceeds 1-1/2 percent from the distribution panel to the motor; in which case, voltage drop shall govern wire sizes. A power factor of 80 percent shall be used for motors in such calculations. De-rate all conductors according to Article 310 of the NEC, especially conductors in ductbanks.

1.08 SPARE PARTS

A. Keys: Furnish two (2) each to Owner.

B. Fuses: Furnish to Owner three (3) spare fuses of each type and rating installed.

C. Fuse Pullers: Furnish one fuse puller to Owner.

PART 2 - PRODUCTS

2.01 MANUAL MOTOR STARTERS

A. Manual Motor Starter: NEMA ICS 2; size as shown on Drawings. AC general-purpose Class A manually operated full-voltage controller for induction motors rated in horsepower, with overload protection, red pilot light and toggle operator.

B. Enclosure: NEMA Type: As indicated on the drawings.

C. Provide manufacturer's equipment ground kit in all starter enclosures.

2.02 MAGNETIC MOTOR STARTERS

A. Magnetic Motor Starters: NEMA ICS 2; AC general-purpose Class A magnetic controller for induction motors rated in horsepower; size 0 minimum.

B. Full Voltage Starting: Reversing and Non-reversing type.

C. Reduced Voltage Starting: Solid-state type, trip current rating shall be adjustable. The overload shall be self-powered, provide phase loss and phase unbalance protection, have a permanent tamper guard and be ambient insensitive. The overload shall have a mechanical test function.

D. Size: NEMA ICS 2; size as shown on Drawings, size 0 minimum.

E. Coil Operating Voltage: 120 volts, 60 Hz.

F. Overload Protection: bimetal or melting alloy.

G. Enclosure: NEMA Type: As indicated on the drawings.

H. Provide manufacturer's equipment ground kit in all starter enclosures.

I. Auxiliary Contacts: NEMA ICS 2; one normally open contact in addition to the seal-in contact.

J. Selector Switches: NEMA ICS 2; HAND/OFF/AUTO, in front cover.

K. Relays: NEMA ICS 2; Provide on-time delay (0-60 sec) relays as indicated on the Drawings.

L. Control Power Transformers: Each magnetic starter shall have a fused primary and a fused 120Vsecondary control transformer, sized for the load, 100 VA minimum. Additionally, the X2 terminal of the control transformer shall be grounded.

M. Combination Motor Starters: Combine motor starters with molded case circuit breaker disconnect in common enclosure.

2.03 CONTROLLER OVERCURRENT PROTECTION AND DISCONNECTING MEANS

A. Molded Case Thermal-Magnetic Circuit Breakers: NEMA AB 1; circuit breakers with integral thermal and instantaneous magnetic trip in each pole.

B. Motor Circuit Protector: NEMA AB 1; circuit breakers with integral instantaneous magnetic trip in each pole.

2.04 FUSES

A. Fuses 600 Amperes and Less: Dual element, time delay, 600 volt, UL Class RK 5. Interrupting Rating: 200,000 rms amperes.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install motor control equipment in accordance with manufacturer's instructions.

B. Motor Starter Panelboard Installation: In conformance with NEMA PB 1.1.

C. Select and install heater elements in motor starters to match installed motor characteristics.

D. Motor Data: Provide neatly typed label inside each motor starter enclosure door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement should be made as per each item of motor control equipment.

4.02 PAYMENT

A. Payment shall be per each item of motor control equipment.

B. Payment shall include furnishing, installing, transporting, labor, incidental materials, grounding, testing, etc. for a complete installation.

END OF SECTION

PART 1 - GENERAL

1.01 SCOPE

A. General purpose contactors and lighting contactors.

1.02 RELATED SPECIFICATIONS

Not Applicable

1.03 CODES AND STANDARDS

A. NEC - National Electrical Code

B. IEEE - Institute of Electrical and Electronics Engineers

C. NEMA - National Electrical Manufacturer's Association

D. UL - Underwriters Laboratories, Inc.

E. ANSI - American National Standards Institute

F. NFPA – National Fire Protection Association

1.04 SUBMITTALS

A. Submit under provisions of Section 16010.

B. Product Data: Include dimensions, size, voltage ratings, current ratings, enclosure type and NEMA sizes.

1.05 OPERATION AND MAINTENANCE DATA

A. Submit under provisions of Section 16010.

B. Maintenance Data: Include instructions for replacing and maintaining coil and contacts.

PART 2 - PRODUCTS

2.01 GENERAL PURPOSE CONTACTORS

A. Description: NEMA ICS 2, AC general purpose magnetic contactor.

B. Coil Voltage: 120 volts, 60 Hertz unless scheduled otherwise.

C. Poles: As scheduled.

D. Size: As scheduled.

E. Enclosure: ANSI/NEMA ICS 6, Type 1 unless scheduled otherwise.

F. Accessories: As scheduled.

2.02 LIGHTING CONTACTORS

A. Description: NEMA ICS 2, magnetic lighting contactor, 100% rated.

B. Configuration: Electrically held, 2 wire control.

C. Coil Voltage: As scheduled.

D. Poles: As scheduled.

E. Contact Rating: 30amperes.

F. Enclosure: ANSI/NEMA ICS 6, Type 1 unless scheduled otherwise.

G. Accessories: As scheduled.

2.03 ACCESSORIES

A. Pushbuttons and Selector Switches: NEMA ICS 2, general duty type.

B. Indicating Lights: NEMA ICS 2, LED push-to-test type.

C. Auxiliary Contacts: NEMA ICS 2, Class A300.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install in accordance with Manufacturer's instructions.

B. The installation must be accessible. The preferred location shall be in the electrical or the mechanical rooms or as shown on the Drawings.

3.02 SCHEDULE

A. See Drawings.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement should be made as per each low voltage contactor.

4.02 PAYMENT

A. Payment shall be per each low voltage contactor.

B. Payment shall include furnishing, installing, transporting, labor, incidental materials, grounding, testing, etc. for a complete installation.

END OF SECTION

PART 1 - GENERAL

1.01 SCOPE

A. Provisions of this Section shall apply to all fuses and fused equipment of 600 volts or less as shown on the Drawings.

B. Furnish and install all fuses as described below.

1.02 Related specifications

Not Applicable

1.03 CODES AND STANDARDS

A. NEC - National Electrical Code

B. IEEE - Institute of Electrical and Electronics Engineers

C. NEMA - National Electrical Manufacturer's Association

D. UL - Underwriters Laboratories, Inc.

E. ANSI - American National Standards Institute

F. NFPA – National Fire Protection Association

PART 2 - PRODUCTS

2.01 STANDARDS

A. All Motor Control Circuit fuses shall be UL Listed Time Delay, Rejection Type Branch Circuit Fuse Class CC, unless otherwise noted. Provide fuse rated for ampacities as shown on the Drawings.

B. Fuses less than 600 Amperes shall be rejection class "R" or "J" type fuses unless indicated otherwise. Fuses shall all be of same class.

C. Fuses protecting Semiconductors shall be fast acting devices intended specifically for such use.

D. Fuse holders shall conform to Class CC requirements sized appropriately for the fuse type(s) listed above.

PART 3 - EXECUTION

3.01 SPARE FUSES

A. Furnish three spare fuses for each size and type of fuse used. Spare fuses shall be turned over to Owner's Representative.

3.02 VOLTAGE RATING

A. All fuses shall have proper voltage rating for the system voltage in which they are fused.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement should be made as per-each type of item.

4.02 PAYMENT

A. The cost of complying with each section of this Specification is included in other bid items.

END OF SECTION

PART 1 - GENERAL

1.01 SCOPE

A. Furnish, assemble, wire, and install lighting controls as specified herein and as shown on the Contract Drawings.

1.02 RELATED SPECIFICATIONS

A. Section 16111 - Conduits and Raceways

B. Section 16120 -Wire and Cable

C. Norfolk Southern – Standard Specifications for Design and Construction, Section LI – Site Lighting

1.02 CODES AND STANDARDS

A. NEC - National Electrical Code

B. IEEE - Institute of Electrical and Electronics Engineers

C. NEMA - National Electrical Manufacturer's Association

D. UL - Underwriters Laboratories, Inc.

E. ANSI - American National Standards Institute

F. NFPA – National Fire Protection Association

1.02 SUBMITTALS

A. Submit shop drawings to Owner's Representative for approval prior to purchase and installation.

PART 2 – PRODUCTS

2.01 CONTACTORS AND RELAYS

A. Furnish electrically held lighting contactors as required on the Drawings. Provide voltage and ampere rating and number of poles as indicated on the Drawings, or as required.

B. Furnish a NEMA 12 enclosure for the lighting contactors and associated equipment to be located in the Electrical Rooms as indicated on the contract drawings.

C. Furnish a NEMA 4/13, 3-position maintained selector switch with HAND-OFF-AUTO positions and legend plate for manual and photocell controlled lighting circuits as shown on the Drawings. Mount this switch on the NEMA 12 enclosure for the lighting contactors to be located in the Electrical Rooms or as indicated on the Drawings.

D. Furnish and install all conduits, mounting equipment, wire, etc. to completely install the lighting control system as shown on the Drawings.

2.02 PHOTO-CONTROLS

A. Provide remote photocell control units with the following features:

1. Enclosed and gasketed for outdoor use in FD cast outlet box.
2. Hermetically sealed photoconductive cell.
3. Operates at temperatures from (-) 40 degrees F to (+) 140 degrees F.
4. Switch on at 3 foot candles and switch off before 12 foot candles natural light level.
5. Thermal relay with silver alloy contacts.
6. 15 second time delay operation.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install and wire lighting contactors, photo-controls, and switches at locations indicated on the Drawings.

B. Install, wire, and adjust photo-control units as required and recommended by Manufacturer.

C. Verify location of photocells with Owner's Representative before final installation.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement should be made as per each lighting control.

4.02 PAYMENT

A. Payment shall be per each lighting control.

B. Payment shall include furnishing, installing, transporting, labor, incidental materials, grounding, testing, etc. for a complete installation.

END OF SECTION

PART 1 - GENERAL

1.1 SCOPE

A. Lightning protection systems shall utilize air terminals (lightning rods) and positive and permanent connections to the ground grid system or electrodes, to divert the lightning current path to ground through conductive paths of adequately low electrical resistance.

B. Protection shall consist of air terminals on the high points of structures connected by suitable down conductors to the network ground grid system or electrode. Air terminals shall consist of pointed copper or copper-clad steel rods.

C. The Contractor shall provide the labor, tools, equipment, and material necessary to install a lightning protection system in accordance with the Plans and as specified herein.

D. Work of this Section includes, but is not limited to:
1. Air terminal system.
2. Interconnecting conductors.
3. Grounding and bonding.
4. Grounding electrode system.
5. Surge Protective Devices

1.2 RELATED SPECIFICATIONS

A. Section 16450 - Grounding and Bonding.

B. Section 16671 – Surge Protective Devices.

1.3 CODES AND STANDARDS

A. Unless otherwise stated, references are to the latest edition of the standard.

B. Underwriter's Laboratory (UL).
1. UL 96A, “Installation Requirements for Lightning Protection Systems.”
2. UL 1449, 3rd Edition 2009 Revision (effective 9/29/2009)

C. National Fire Protection Association (NFPA).
1. NFPA 70, “The National Electrical Code.”
2. NFPA 780, “Standard for the Installation of Lightning Protection Systems.”

D. Lightning Protection Institute (LPI).
1. LPI-175, “Standard of Practice.”
2. LPI-176, “Standard of Materials.”

1.4 QUALITY ASSURANCE

A. General

1. Provide a complete lightning protection system including all items required for protection against damage by lightning.
2. Provide a lightning protection system to cover all areas of the building or structure.

B. Installers Qualifications.
1. Engage a qualified installer to design and install the lightning protection system.
2. Minimum of 5 years experience in design and installation of lighting protection systems.
3. Current UL listing (Category OWAY) for Lightning Protection Installation.
4. Documented record for successful completion of not less than 5 installations of similar scope to this project.
5. Provide products that are UL listed for lightning protection use.

1.5 PERFORMANCE REQUIREMENTS

A. Protect the entire building or specific outdoor exposed structures and systems including pole mounted high mast lighting, roof mounted equipment, electrical services, antennas, security services, and communications systems.

B. Underwriters' Laboratories Master Label.
1. Furnish a UL Master Label as evidence that the installation meets U.L. requirements.
2. Have the Owner sign an application blank for a UL Master Label.
3. Have the brass "Master Label" plate sent the Owner from UL through the Manufacturer of the equipment.

1.6 SUBMITTALS

A. General: Submit the following according to the Conditions of the Contract.
1. Product data for each component. Include electrical ratings, dimensions, mounting position, mounting method, vertical supports, materials, fire stops, and weather stops.
2. Materials list of lightning protection system components showing manufacturer's catalog number and quantity.
3. Shop drawings.
    a. Not smaller than 1/8" = 1'-0" scale.
    b. Show the type, size, and locations of the following:
        1) Counterpoise.
        2) Ground rods.
        3) Down conductors.
        4) Through roof/through wall assemblies.
        5) Roof conductors.
        6) Air terminals.
        7) Bonding connections.
    c. Include details of air terminal base and cable fastener installations.

B. Quality Control Submittals
1. Special Guarantees and Warrantees.
2. Installers Certification.
    a. Certification that firm meets specified qualifications.

b. List of completed projects with contact information.

3. Project record documents that accurately record installed locations of all equipment and components.
4. Test reports for all inspection and testing.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Receive, store, protect, and handle products according to NECA 1 Standard Practices for Good Workmanship in Electrical Construction.

B. Handle conductors to prevent nicking, kinking, gouging, flattening, or otherwise deforming or weakening conductor or impairing its conductivity.

1.8 SEQUENCING AND SCHEDULING

A. Coordinate installation of lightning protection system with the installation of other building systems and components that require bonding to lightning protection systems.

B. Coordinate inspections to allow components be inspected before being covered with concrete or other building materials.

PART 2 - PRODUCTS

2.1 LIGHTNING PROTECTION SYSTEM

A. General
1. Provide materials and components that conform to NFPA 780 and UL 96 Standard for Safety for Lightning Protection Components.
2. All rods, cables, ground rods, and connectors used in the system shall carry an UL Label "A" & "B" and all lightning air terminals shall carry the Manufacturer's name.

B. Air terminals:
1. Provide 1/2 inch-diameter, rounded-tip, solid-copper air terminals.
2. Air terminal tips shall have a tip radius of curvature of from 3/16 inch to 1/2 inch.
3. Provide a cast base for each air terminal that matches the air terminal material, has a bolted pressure type cable connector, will support the terminal in a vertical position, and is suitable for the surface to which it will be attached.

C. Structures not exceeding 23m in height shall be protected with Class I materials per NFPA 780 Table 3-1.1(a). Structures exceeding 23m in height shall be protected with Class II materials per Table 3-1.1(b).

D. Conductors: Conductors shall consist of commercially pure copper cable, sized in accordance with NFPA Code.

E. Ground Connection: Ground connection shall be of 3/4-inch x 10'- 0" copper clad rod.

F. Air Terminal and Conductor Fasteners.

1. Provide fasteners made from an approved type of noncorrosive metal.
2. For installations on standing seam metal roofs provide air terminal bases and cable fasteners that clamp to the standing seams and are compatible with the roofing system and the lightning protection system materials.
3. For installations on membrane roofing or other surfaces that must not be penetrated provide attachments for air terminal bases and cable fasteners that do not depend on adhesive alone for proper performance.
    a. Provide adhesives for cable fasteners and air terminal bases that are compatible with surface or roofing material to which bases or fasteners are to be attached.
    b. Provide bases and fasteners that will stay in position and prevent overturning by using gravity or mechanical attachment.

G. Surge Protective Devices.
1. Provide surge protective devices for all power, control, and communications conductors entering the building which are specifically required to obtain a UL Master Label.
2. Refer to Section 16671, surge protective devices.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General
1. All ungrounded sizable metallic objects within 6' of the system or metal connected to the system shall be bonded to the system with approved fittings and conductor.
2. Bond lightning protection system to the protected building's underground grounding electrode system used for the electrical service entrance using a bare #4/0 copper conductor and exothermic weld.
3. Copper materials connecting to steel shall be lead-coated.
4. Connection between other dissimilar metals shall be made with approved bimetallic connectors.
5. Bonding of all metal Work and ventilators on roof shall be included in the above.
6. Where conductors or air terminals pass through roof, they shall be properly flashed to conform to the roofing requirements.
7. All materials shall be fastened to eliminate any possibility of displacement and subsequent maintenance.

B. Air Terminals
1. Install air terminals on ridges, parapets, and around the perimeter of buildings with flat roofs at spacing not to exceed 20 feet. Install supplemental air terminals as required by and NFPA 780. Permanently and rigidly attach air terminals to prevent overturning. Install swivel adapters as required to position air terminals vertically.
2. Air terminals shall not extend higher than 24 inches except with individual approval or as required by OSHA. Terminals 23 inches and less shall be spaced 20 feet apart.
3. Terminals 24 inches and higher shall be spaced 25 feet apart or as required by codes.

C. Conductors: Conductors shall be run concealed.

D. Ground Connection:
   1. Drive ground rod to the required depth to reach permanent moisture but in no case less than 11'-6". In case of rock ledge or other conditions making compliance impossible, trench or other grounding will be permitted, providing it will pass UL requirements.
   2. Bond a minimum of two lightning protection down conductors and ground rods to the building's grounding electrode conductor loop or grid system.

E. Conductor Fasteners: Space 3'-0" O.C. max.

F. High Mast Light Poles shall each include a pole top mounted air terminal, ground connection and integral lightning arrester furnished by manufacturer as part of the fixture and pole assembly. Contractor shall provide ground rod, ground conductor and connection to pole base and ground rod at each pole.

G. Wooden Poles used for area or roadway lighting or CCTV cameras
   1. Each pole will have a ¾ inch X 10 ft ground rod or buried at the base of the pole
   2. A number 6 hard drawn copper conductor will be connected to the rod and ran up the length of the pole extending at least 18 inches beyond the top of the pole
   3. The conductor will be stapled or strapped every 18 inches up the pole length for support

H. Roof Top Packaged Air Handling Units: Special care shall be taken in installing conductors and air terminals on roof top packaged air handling units.
   1. No penetrations shall be made through roofs or walls of the units.
   2. No holes shall be drilled in roofs or sides for mounting air terminals or fastening conductors.
   3. Conductors shall be fastened to roofs and sides with a silicone sealer.

3.2 FIELD QUALITY CONTROL

A. Use test instruments that are capable of measuring within plus or minus 10 percent of the required reading and have current calibration.

B. Test the lightning protection grounding electrode system using the "fall of potential" method. Make test before any connections are made to the electrode. Verify that resistance to earth reading is 25 ohms or less. Supplement grounding electrode if resistance exceeds 25 ohms. Use test instruments that are designed specifically for earth resistance testing. Provide certified test results to the Owner's Representative.

C. Inspect and test the lightning protection system to determine:
   1. That the system complies with the stated requirements.
   2. That all required bonds are in place and are secure.
   3. Take corrective action to correct deficiencies.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

A. Measurement should be made as per each lightning protection system.

4.2 PAYMENT

A. Payment shall be per each lightning protection system.

B. Payment shall include furnishing, installing, transporting, labor, incidental materials, grounding, testing, etc. for a complete installation.

END OF SECTION 16601

PART 1 - GENERAL

1.01 SCOPE

A. This section consists of the Contractor furnishing all labor, materials and equipment necessary for standby emergency power generator system installations with all accessories and incidental items required to affect proper working capability.

B. Work includes:

1. The standby power system consists of a liquid cooled engine, an AC alternator, governor, coupling and system controls which must have been tested as a complete unit on a representative engineering model as required, with all necessary accessories for a complete operating system, including but not limited to the items as specified hereinafter.

2. Provide an automatic transfer switch described elsewhere in this specification so that the systems come on line fully automatically, and on restoration of utility power automatically retransfers load to normal power, shuts down the generator and returns to readiness for another operating cycle.

1.02 RELATED SPECIFICATIONS

Not Applicable

1.03 CODES AND STANDARDS

A. NEC - National Electrical Code

B. IEEE - Institute of Electrical and Electronics Engineers

C. NEMA - National Electrical Manufacturer's Association

D. UL - Underwriters Laboratories, Inc.

E. ANSI - American National Standards Institute

F. IPCEA - Insulated Power Cable Engineers Association

G. NFPA – National Fire Protection Association

1.04 SUBMITTALS

A. Provide six complete sets of Manufacturer's product engineering information for approval, prior to production release, showing all engine, generator, automatic transfer switch and other system components. Submittals shall demonstrate compliance with these Specifications.

1.05 MANUFACTURER QUALIFICATIONS

A. These systems shall be supplied by a Manufacturer who has been regularly engaged in the production of engine-generator sets, automatic transfer switches, and associated controls for a minimum of five years, so there is one source of supply and responsibility.

B. To be classified as a Manufacturer, the builder of the generator set must manufacture at least the engine or alternator.

C. The Manufacturer shall have printed literature and brochures describing the standard series specified, not a one of a kind fabrication.

PART 2 - PRODUCTS

2.01 ENGINE-GENERATOR SET

A. Engine:

1. The prime mover shall be a liquid cooled, diesel fueled, turbo charged engine of 4-cycle design.
2. The engine is to be cooled with a unit mounted radiator, fan, water pump, and closed coolant recovery system providing visual diagnostic means to determine if the system is operating with a normal engine coolant level. The radiator shall be designed for operation in 122 degrees Fahrenheit, 50 degrees Celsius ambient temperature.
3. The intake air filter with replaceable element must be mounted on the unit. Full pressure lubrication shall be supplied by a positive displacement lube oil pump. The engine shall have a replaceable oil filter with internal bypass and replaceable elements. Engine coolant and oil drain extension must be provided to outside the mounting base for cleaner and more convenient engine servicing. A fan guard must be installed for personnel safety.
4. The engine shall have a battery charging DC alternator with a transistorized voltage regulator. Remote 2-wire starting shall be by a solenoid shift, electric starter.
5. Engine speed shall be governed by electronic isochronous governor to maintain alternator frequency within 0.5% from no load to full load alternator output. Steady state regulation is to be 0.25%.
6. The engine fuel system shall be designed for operation on No. 2 diesel fuel. A secondary fuel filter, water separator, manual fuel priming pump, fuel shut-off solenoid and all fuel lines must be installed at the point of manufacture.
7. Sensing elements shall be located on the engine for low oil pressure shutdown, high coolant temperature shutdown, low coolant level shutdown, over-speed shutdown and over-crank shutdown. These sensors are to be connected to the control panel using a wiring harness with the following features: wire number labeling on each end of the wire run for easy identification, a molded rubber boot to cover the electrical connection on each sensor to prevent corrosion and all wiring to be run in flexible conduit for protection from the environment and any moving objects.
8. The engine shall have an engine mounted, thermostatically controlled water jacket heater to aid in quick starting. It will be of adequate wattage as recommended by the engine Manufacturer and sized for operation on a 3 phase, 4 wire system. The contractor shall provide a proper branch circuit from the normal utility power bus.
9. Provide the following items installed at the factory:
    a. Provide a 2 amp automatic float battery charger manufactured by the engine-generator

set supplier. It is to be of a solid-state design and self-regulating to prevent overcharging the system battery. The battery charger is to be factory installed on the Generator Set or in the transfer switch. Battery charger shall be equipped with a low battery alarm. The Contractor shall provide a proper branch circuit from the emergency power bus, if required.

b. The unit will provide means for attaching a flexible coupling between the engine radiator and the enclosure cooling air louver.

c. A heavy duty, lead acid battery of adequate voltage and amperage capacity to start and operate the engine shall be provided by the Generator Set Manufacturer. The batteries shall be sized for the allowable number of failed starts specified below followed by a successful start for the ambient conditions specified. Provide all inter-cell and connecting battery cables as required.

d. The Manufacturer shall supply a stainless steel flex connector from the engine exhaust manifold to the exhaust system.

10. The fuel system for each generator shall include enough fuel for 24 hours of operation at full load. Tank shall be double walled (with tank rupture alarm), UL approved, base mounted fuel tank. It shall have the structural integrity to support the engine-generator set. Minimum features shall include all welded construction, a lockable fuel filler cap, fuel gauge, low fuel level alarm, fuel line check valve and fittings for fuel supply, return, fill and vent. This tank must be supplied and warranted by the engine-generator set Manufacturer and be factory installed.

B. Alternator:

1. The alternator shall be a 4-pole revolving field type, 12 lead, wired for 277/480 VAC, three phase, 60 Hz upsized to the specified KW ratings to support the required KVA with a brushless exciter. Photosensitive components will not be permitted in the rotating exciter. The stator shall be direct connected to the engine to ensure permanent alignment. The generator shall meet temperature rise standards for class "H" insulation and conform to MIL-1-24092, Type "M", class 155. All leads must be extended into the AC connection panel. The alternator shall be protected by internal thermal overload protection and an automatic reset field circuit breaker.

2. One step load acceptance shall be 100% of nameplate kW rating and meet the requirements of NFPA 110 paragraph 5-13.2.6. The engine-generator set shall be so designed that voltage dip upon application of nameplate kW/kVA shall not exceed 12.5% with recovery to stable operation within 2 seconds. The generator set and regulator must sustain at least 90% of no load voltage for 10 seconds with 250% of rated load at near zero power factor connected to its terminals.

3. A solid state voltage regulator designed and built by the engine-generator set manufacturer must be used to control output voltage by varying the exciter magnetic field to provide + or - 1% regulation during stable load conditions. Should an extremely heavy load drop the output frequency, the regulator shall have a voltage droop of 4 volts/hertz to maximize motor starting capability. The frequency at which this droop operation begins must be adjustable, allowing the generator set to be properly matched to the load characteristics ensuring optimum system performance. Additional rheostats for matching generator voltage, droop, and stability

characteristics to the specific load conditions must be available.

4. The voltage regulator must contain a limiting circuit to prevent output voltage surges in excess of 125% of rated voltage during generator set operation. On loss or near loss of the sensing signal, the voltage regulator must shutdown to prevent an over-voltage condition from occurring unless the specific application requires 300% of rated current is allowed to flow through the electrical distribution circuit(s) for ten (10) seconds. Voltage regulators that are not capable of both modes of operation are not acceptable. LED indication will be provided on the regulator to monitor the sensing (yellow), excitation (green), and output circuit (red).
5. A panel that is an integral part of the generator set must be provided to allow the installer a convenient location in which to make electrical output connections. An isolated neutral lug must be included by the generator set manufacturer to ensure proper sizing.
6. The electric plant shall be mounted with vibration isolators on a welded steel base which shall permit suitable mounting to any level surface.
7. A thermal magnetic UL listed main line circuit breaker rated as shown on the drawings must be mounted in the AC connection panel. The line side connections are to be made at the factory. A system utilizing a manual reset field circuit breaker and current transformers is unacceptable.
8. Contractor shall provide analog type meters to monitor voltage, ampere and frequency outputs of the generator.

C. Controls:

1. All engine alternator controls and instrumentation shall be designed, built, wired, tested and shock mounted in a NEMA 3R enclosure to the engine generator set by the manufacturer. It shall contain panel lighting, a fused DC circuit to protect the controls and a +/-5% voltage adjusting control. This panel must be able to be rotated 90 degrees in either direction for correct installation.
2. Safety shutdown monitoring system shall include solid state engine monitor with individual lights and one common external alarm contact indicating, as a minimum, the following conditions: Over-crank shutdown, Over-speed shutdown, High Coolant Temperature shutdown, Low Coolant Level shutdown, Low Oil Pressure shutdown. Monitoring system shall include lamp test switch for manual reset of tripped conditions. Engine RPM is to be monitored by an independent permanent magnet sensor. If there is a failure in this circuit, then engine must shutdown immediately and illuminate a Loss of RPM Sensor shutdown.
3. The engine-generator set shall contain a complete engine start-stop control which starts the engine on closing contacts and stops the engine on opening contacts. A variable cyclic cranking limiter shall be provided to open the starting circuit after up to 5 attempts if the engine has not started within that time. Engine control modules must be solid state plug-in type for high reliability and easy service. The engine controls shall also include a 3-position selector switch with the following positions: OFF/MANUAL/AUTO.
4. Engine instrumentation shall consist of an oil pressure gauge, coolant temperature gauge, DC ammeter and an engine run hour-meter located on the unit control panel.

D. Unit Accessories:

1. Weather protective enclosure: The engine-generator set shall be factory enclosed in a heavy gauge steel enclosure constructed with corner posts, coated with electro-statically applied zinc and finished with baked powder paint. The enclosure is to have large, easily opened doors to allow access to the engine, alternator and control panel. Enclosure shall be NEMA 4 rated. Each door is to be fitted with lockable hardware with identical keys. Padlocks do not meet this specification.
2. Exhaust silencer(s) shall be provided of the size as recommended by the manufacturer and shall be of critical grade. The silencer(s) shall be mounted on the weather protective enclosure with the use of a flexible, seamless, stainless steel exhaust connection and rain cap. All components must be properly sized to assure operation without excessive back pressure when installed.
3. Remote Annunciator: Each generator shall be provided with a remote annunicator. The remote unit shall indicate Engine run, Over-crank shutdown, Over-speed shutdown, High Coolant Temperature shutdown, Low Coolant Level shutdown, Low Oil Pressure shutdown. See drawing for remote annunicator locations. Provide communication wiring and related hardware for communication over the distance shown.

2.02 AUTOMATIC TRANSFER SWITCH

A. General: The automatic transfer switch shall be furnished by the manufacturer of the engine-generator set so as to maintain system compatibility and local service responsibility for the complete emergency power system. It shall be listed by Underwriter's Laboratory Standard 1008 with circuit breaker protection. Representative production samples of the transfer switch supplied shall have demonstrated through tests the ability to withstand at least 10,000 mechanical operation cycles. One operation cycle is the electrically operated transfer from normal to emergency and back to normal. Wiring must comply with NEC table 3736(b). The manufacturer shall furnish schematic and wiring diagrams for the particular automatic transfer switch and a typical wiring diagram for the entire system.

B. Ratings and Performance: The automatic transfer switch for the generators shall be rated for continuous operation in ambient temperatures of -20 Degrees Fahrenheit (-30 Degrees Celsius) to +140 Degrees Fahrenheit (+60 Degrees Celsius). Main power switch contacts shall be rated for 480 Volt AC minimum. The transfer switch supplied shall have a minimum withstand and closing rating when fuse protected of 200,000 amperes. Where the line side overcurrent protection is provided by circuit breakers, the short circuit withstand and closing ratings shall be 22,000 amperes RMS. These RMS symmetrical fault current ratings shall be the rating listed in the UL listing or component recognition procedures for the transfer switch. All withstand tests shall be performed with the overcurrent protective devices located external to the transfer switch.

C. Construction:

1. The transfer switch shall be double throw construction, positively electrically and mechanically interlocked to prevent simultaneous closing and mechanically held in both normal and emergency positions. Independent break before make action shall be used to positively prevent dangerous source to source connections. When switching the neutral, this

action prevents the objectionable ground currents and nuisance ground fault tripping that can result from overlapping designs. The transfer switch shall be approved for manual operation. The electrical operating means shall be by electric solenoid. Every portion of the contactor is to be positively mechanically connected. No clutch or friction drive mechanism is allowed, and parts are to be kept to a minimum. This transfer switch shall not contain integral overcurrent devices in the main power circuit, including molded case circuit breakers or fuses.

2. The transfer switch electrical actuator shall have an independent disconnect means to disable the electrical operation during manual switching. Maximum electrical transfer time in either direction shall be 160 milliseconds, exclusive of time delays. Main switch contacts shall be high pressure silver alloy contacts to resist burning and pitting for long life operation.
3. There shall be two SPDT, 10 ampere, 250 volt auxiliary switches on both normal and emergency sides, operated by the transfer switch. Full rated neutral bar with lugs for normal, emergency and load conductors shall be provided inside the cabinet.

D. Controls:

1. All control equipment shall be mounted on the inside of the cabinet door in a metal lockable enclosure with transparent safety shield to protect all solid-state circuit boards. This will allow for ease of service access when main cabinet lockable door is open, but to prevent access by unauthorized personnel. Control boards shall have installed cover plates to avoid shock hazard while making control adjustments. The solid state voltage sensors and time delay modules shall be plug-in circuit boards with silver or gold contacts for ease of service.
2. A solid state under voltage sensor shall monitor all phases of the normal source and provide adjustable ranges for field adjustments for specific application needs. Pick-up and drop-out settings shall be adjustable from a minimum of 70% to a maximum of 95% of nominal voltage. A utility sensing interface shall be used, stepping down line voltage to 24VAC, helping to protect the printed circuit board from voltage spikes and increasing personnel safety when troubleshooting.
3. Signal the engine-generator set to start in the event of a power interruption. A set of contacts shall close to start the engine and open for engine shutdown. A solid-state time delay start (adjustable, .1 to 10 seconds) shall delay this signal to avoid nuisance start-ups on momentary voltage dips or power outages.
4. Transfer the load to the engine-generator set after it reached proper voltage and frequency. A solid-state time delay (adjustable, 5 seconds-3 minutes) shall delay this transfer to allow the engine-generator to warm-up before application of load. There shall be a switch to bypass this warm-up timer when immediate transfer is required.
5. Retransfer the load to the line after normal power restoration. A return to utility timer (adjustable, 1-30 minutes) shall delay this transfer to avoid short term normal power restoration.
6. The operating power for transfer and retransfer shall be obtained from the source to which the load is being transferred. Controls shall provide an automatic retransfer of the load from emergency to normal if the emergency source fails with the normal source available.

7. Signal the engine-generator to stop after the load retransfers to normal. A solid-state engine cool down timer (adjustable, 1-30 minutes) shall permit the engine to run unloaded to cool down before shutdown.
8. Provide an engine minimum run timer (adjustable, 5-30 minutes) to ensure an adequate engine run period.
9. Provide a solid state plant exercise clock to start the generator set exercise period. Clock shall have a one week cycle and be powered by the load side of the transfer switch. A battery must be supplied to maintain the circuit board clock operation when the load side of the transfer switch is de-energized. Include a switch to select if the load will transfer to the engine generator set during the exercise period.
10. Control shall include a digital display interface enabling the operator to establish unit exercise time within a twenty four hour period. Additional switch settings enable any combination of days within a week for unit exercise. This control is completely self-contained, eliminating the need for the operator to handle pins and jumper wires.
11. The transfer switch shall have a time delay neutral feature to provide a time delay (adjustable, 1-10 seconds) during the transfer in either direction, during which time the load is isolated from both power sources. This allows residual voltage components of motors or other inductive loads (such as transformers) to decay before completing the switching cycle. A switch will be provided to bypass all transition features when immediate transfer is required.
12. The transfer switch shall have an in-phase monitor which allows the switch to transfer between live sources if their voltage waveforms become synchronous within 20 electrical degrees within 10 seconds of transfer initiation signal. A switch must be provided to bypass this feature if not required.
13. If the in-phase monitor will not allow such a transfer, the control must default to time delay neutral operation. Switches with in-phase monitors which do not default to time delay neutral operation are not acceptable.
14. Front mounted controls shall include a selector switch to provide for a NORMAL TEST mode with full use of time delays, FAST TEST mode which bypasses all time delays to allow for testing the entire system in less than one minute, or AUTOMATIC mode to set the system for normal operation.
15. Provide bright lamps to indicate the transfer switch position in either UTILITY (white) or EMERGENCY (red). A third lamp is needed to indicate STANDBY OPERATING (amber). These lights must be energized from utility or the engine-generator set.
16. Provide manual operating handle to allow for manual transfer. This handle must be mounted inside the lockable enclosure so accessible only by authorized personnel.
17. Provide a safety disconnect switch to prevent load transfer and automatic engine start while performing maintenance. This switch will also be used for manual transfer switch operation.
18. Provide LED status lights to give a visual readout of the operating sequence. This shall include utility on, engine warm-up, engine warm-up bypass, standby voltage "ready", standby frequency "ready", standby on, transfer to standby, in-phase monitor, time delay neutral, return to utility, engine cool down, engine minimum run and fast test mode.

19. Provide a transfer switch with non-volatile memory so that a backup battery is not needed.
20. Provide built-in diagnostics with LCD display for immediate troubleshooting.
21. Provide an Event Log to track Date, Time and Reason for action taken.

E. Miscellaneous Transfer Switch Equipment: The transfer switches mechanism and controls are to be mounted in a NEMA rated enclosure suitable for the location in which the transfer switch equipment is mounted.

PART 3 - EXECUTION

3.01 FACTORY TESTING

A. Before shipment of the equipment, the engine-generator set shall be tested under rated load for performance and proper functioning of control and interfacing circuits. Tests shall include:
   1. Verifying all safety shutdowns are functioning properly.
   2. Single step load pick-up per NFPA 110-1985, Paragraph 5-13.2.6.
   3. Transient and voltage dip responses and steady state voltage and speed (frequency) checks.

3.02 OWNER'S MANUALS

A. Three (3) sets of owner's manuals specific to the product supplied must accompany delivery of the equipment. General operating instruction, preventive maintenance, wiring diagrams, schematics and parts exploded views specific to this model must be included.

3.03 INSTALLATION

A. Contractor shall install the complete electrical generating system including all fuel connections in accordance with the manufacturer's recommendations as reviewed by the Engineer.

3.04 SERVICE

A. Supplier of the electric plant and associated items shall have permanent service facilities in this trade area. These facilities shall comprise a permanent force of factory trained service personnel on 24 hour call, experienced in servicing this type of equipment, providing Warranty and routine maintenance service to afford the Owner maximum protection. Delegation of this service responsibility for any of the equipment listed herein will not be considered fulfillment of these Specifications. Service contracts shall also be available.

3.05 WARRANTY

A. The standby electric generating system components, complete engine-generator and instrumentation panel shall be warranted by the Manufacturer against defective materials and factory workmanship for a period of 12 months. Such defective parts shall be repaired or replaced at the Manufacturer's option, free of charge for travel and labor. The warranty period

shall commence when the standby power system is first placed into service. Multiple warranties for individual components (engine, alternator, controls, etc.) will not be acceptable. Satisfactory warranty documents must be provided. Also, in the judgment of the specifying authority, the Manufacturer supplying the warranty for the complete system must have the necessary financial strength and technical expertise with all components supplied to provide adequate warranty support.

3.06 STARTUP AND CHECKOUT

A. The supplier of the electric generating plant and associated items covered herein shall provide factory trained technicians to check out the completed installation and to perform an initial startup inspection to include:

1. Ensuring the engine starts (both hot and cold) within the specified time.
2. Verification of engine parameters within specification.
3. Set no load frequency and voltage.
4. Test all automatic shutdowns of the engine-generator.
5. Perform a 4 hour, full load test of the electric plants, ensuring full load frequency and voltage are within specification by using a resistive load bank.
6. Perform a 1 hour test of the electric plants, ensuring frequency and voltage are within specification by using the building load.

B. The Engineer of Record may witness all generator and transfer switch tests. Schedule all tests in advance with the Engineer.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement should be made as per each emergency generator system by type.

4.02 PAYMENT

A. Payment shall be per each emergency generator system.

B. Payment shall include furnishing, installing, transporting, labor, incidental materials, grounding, testing, etc. for a complete installation.

END OF SECTION

PART 1 - GENERAL

1.1 SCOPE

A. These specifications describe the electrical and mechanical requirements for modular, high-energy surge protective devices (SPDs) to be located where shown on the drawings and as specified in other related documents.

1.2 RELATED SPECIFICATIONS

A. Related Sections include the following:
   1. Division 16601 Section “Lightning Protection Systems”.

1.3 STANDARDS

A. Standards : The specified system shall be designed, manufactured, tested and installed in compliance with the following codes and standards:
   1. Underwriters Laboratories; UL 1449 3rd Edition 2009 Revision (effective 9/29/2009)
   2. Institute of Electrical and Electronic Engineers (ANSI/IEEE C62.11, C62.34, C62.41, C62.45)
   3. Institute of Electrical and Electronic Engineers 1100 Emerald Book
   4. Federal Information Processing Standards Publication 94 (FIPS PUB 94)
   5. National Fire Protection Association (NFPA 20, 70, 75 and 780)

1.4 SUBMITTALS

A. Product Data: For each type of product indicated. Manufacturers shall submit independent test data from a nationally recognized testing laboratory verifying the following: life cycle testing, overcurrent protection, UL1449 3rd Edition, noise attenuation and surge current capacity. Failure to do so will result in product disapproval.

B. Equipment Manual: The manufacturer shall furnish an installation manual with installation, startup, and operating instructions for the specified system.

C. Drawings: Electrical and mechanical drawings shall be provided by the manufacturer that show unit dimensions, weights, component and connection locations, mounting provisions, connection details and wiring diagram.

1.5 QUALITY ASSURANCE

A. Codes: Perform all work in compliance with NFPA 70, National Electrical Code (NEC) and all applicable federal, state, and local codes and regulatory requirements.

B. Manufacturer: The specified interconnect assembly shall be designed and manufactured in the USA by a qualified manufacturer of SPD products. The manufacturer shall have at least 5 years experience in the design, testing, and manufacturing of surge protective devices.

C. Installer: Minimum of 3 years successful installation experience on projects utilizing equipment similar to that required for this project.

D. Source Limitations: Obtain suppression devices and accessories through one source from a single manufacturer.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.6 PROJECT CONDITIONS

A. Service Conditions: Rate surge protective devices for continuous operation under the following conditions, unless otherwise indicated:
   1. Operating Frequency: 50 or 60 Hz.
   2. Operating Temperature: -40 to 140 deg F.
   3. Humidity: 0 to 95 percent, non-condensing.
   4. Operating Altitude: 0 to 18,000 feet above sea level.

B. Warranty: The manufacturer shall provide a 10-year full parts replacement warranty

PART 2 - PRODUCTS

2.1 DISTRIBUTION CLASS ARRESTERS

A. Equipment shall employ metal oxide varistor technology, mounted in ceramic housing. Equipment shall be rated 3 kV on 4,160 V distribution system, 9 kV on 12,470 V distribution system, and 10 kV on 13,800 V distribution system. Equipment shall provide line-to-ground protection. Similar to Cooper Power Systems VariSTAR.

B. Equipment for dead-front pad mounted applications shall employ metal oxide varistor technology mounted in premolded rubber elbows. Equipment shall be rated 3 kV on 4,160 V distribution system, 9 kV on 12,470 V distribution system, and 10 kV on 13,800 V distribution system. Equipment shall provide line-to-ground protection. Similar to Cooper Power Systems M.O.V.E. Elbow.

C. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the following: Cooper Power Systems, General Electric, and McGraw-Edison.

2.2 SERVICE ENTRANCE SUPPRESSORS

A. UL Listed Type 1 located on the line side of the first overcurrent protective device.

B. Peak Surge Current Capacity – 200 kA per mode.

C. The UL 1449 Nominal Discharge Current Rating – 20kA.

D. Protection Modes: The SPD shall provide protection in all modes: L-N or L-L, L-G and N-G (where applicable). Note: L = Line, G = Ground, N = Neutral

E. UL 1449 Voltage Protection Ratings: The maximum UL 1449 listed surge ratings for each and/or all of the specified protection modes shall not exceed the following:

System Voltage	UL 1449 3rd Edition VPR			
	L-N	N-G	L-G	L-L
120/240	800 v	700 v	900 v	1200 v
120/208	800 v	700 v	900 v	1200 v
240			1200 v	2000 v
277/480	1200 v	1800 v	1200 v	2000 v
480			2000 v	2000 v

F. Surge Protective Device Description: with the following features and accessories:
1. LED indicator lights for power and protection status.
2. Audible alarm, with silencing switch, to indicate when protection has failed.
3. One set of Form C contacts, for remote monitoring of protection status.
4. NEMA 4X Enclosure.

G. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the following: Liebert, Current Technology, Ditek, LEA International.

2.3 PANELBOARD SUPPRESSORS

A. UL Listed Type 2 located on the load side of the first overcurrent protective device.

B. Peak Surge Current Capacity – 100 kA per mode.

C. The UL 1449 Nominal Discharge Current Rating – 20kA.

D. Surge Protective Device Description: Modular design with field-replaceable modules and the following features and accessories:
1. LED indicator lights for power and protection status.
2. Audible alarm, with silencing switch, to indicate when protection has failed.
3. One set of Form C contacts, for remote monitoring of protection status.
4. NEMA 4X Enclosure.

2.4 VOICE, DATA AND SIGNAL SUPPRESSION MODULES

A. Surge Protective Device Description: Modular design with field-replaceable modules and the following features and accessories:
1. Minimum protection of 2 circuit pairs per module.
2. Protection of 4-20mA current loops, alarm panel NAC, SLC and IDC loops.
3. Suitable for AC and DC circuits.

4. Service voltage levels shall include 0-5 Volts, 12 volts, 24 Volts, 36 Volts, 48 Volts, 75 Volts.
5. Modular or DIN Rail mounted base with plug-in protection module.
6. Max surge current: 20kA
7. Max continuous current: 5 amps

PART 3 - EXECUTION

3.1 INSTALLATION OF SURGE PROTECTIVE DEVICES

A. The installing contractor shall install the SPD with as short of conductors as practically possible and twist the SPD input conductors together to reduce conductor inductance. The contractor shall follow the SPD manufacturer's recommended installation practices as found in the installation, operation and maintenance manual and comply with all applicable codes. Type 2 SPDs shall be connected to circuit breakers or fuses as required by the SPD's UL Listing.

3.2 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A/486B.

3.3 FIELD QUALITY CONTROL

A. Testing: Perform the following field quality-control testing:
   1. After installing surge protective devices, but before electrical circuitry has been energized, test for compliance with requirements.
   2. Complete startup checks according to manufacturer's written instructions.
   3. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Section 7.19. Certify compliance with test parameters.

B. Repair or replace malfunctioning units. Retest after repairs or replacements are made.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

A. Measurement should be made as per each surge suppression device.

4.2 PAYMENT

A. Payment shall be per each stand-alone surge suppression device.

B. Payment shall include furnishing, installing, transporting, labor, incidental materials, grounding, testing, etc. for a complete installation.

C. The cost of complying with this Specification for high mast lighting, outdoor medium voltage equipment including pad mounted switches and transformers, switchgear, switchboard,

panelboard and MCC mounted transient voltage suppression systems is included in other bid items.

END OF SECTION 16671

PART 1 - GENERAL

1.01 SCOPE

A. The work described in this specification will be performed by an independent electrical power distribution systems testing consultant (TC) whose primary business is in high voltage and low voltage testing services. This project shall provide the required specialized cleaning, repair, adjustment, calibration, maintenance and testing of all primary and secondary components of the electrical distribution system, as specified herein. This includes all customer-owned incoming primary apparatus, switchgear, transformers, instrumentation, controls, distribution cabling systems, and all building service equipment, i.e.: transformers, instrumentation and the secondary main building services.

B. Any item found to be out of tolerance, or in any other way defective as a result of the required testing, shall be reported to the Engineer of Record or owner's representative immediately. Procedure for repair and/or replacement will be outlined. After appropriate corrective action is completed the item shall be re-tested.

C. All new and existing equipment, apparatus and work shall be tested to insure its proper and safe operation in accordance with these specifications, and manufacturer's standards.

D. All equipment shall be tested and inspected in accordance with the latest applicable National Electrical Testing Association (NETA) standards and manufacturers' instructions. Submit four (4) copies of all test reports on NETA or similar printed forms. All individual components of an assembly (except cable) shall be tested with the component in its final connected stage in order to confirm the actual intended operation of the device.

E. The TC will be responsible for the coordination of construction and testing activities. The electrical contractor will be responsible for the cost of the testing consultant.

1.02 RELATED SPECIFICATIONS

Not Applicable

1.03 CODES AND STANDARDS

A. NEC - National Electrical Code

B. IEEE - Institute of Electrical and Electronics Engineers

C. NEMA - National Electrical Manufacturer's Association

D. UL - Underwriters Laboratories, Inc.

E. ANSI - American National Standards Institute

F. IPCEA - Insulated Power Cable Engineers Association

G. NFPA – National Fire Protection Association

1.04 SUBMITTALS

A. The test report shall include the following:

1. Summary of project.
2. Description of equipment tested.
3. Description of test.
4. Test results.
5. Conclusions and recommendations.
6. Appendix, including appropriate test forms.
7. List of test equipment used and calibration date.

B. Furnish four (4) copies of the completed report to the Engineer no later than thirty (30) days after completion of the project, unless directed otherwise.

1.05 LIST OF EQUIPMENT TO BE CLEANED AND TESTED:

A. General Inspection and Cleaning of all Electrical Equipment

B. Infrared Scanning of Electrical Distribution Equipment.

C. Grounding Systems

D. Lightning/Surge Arresters

E. Metering and Instrumentation

F. Battery Systems/UPS

G. Mechanical and Electrical Interlock Systems

H. Transformers

I. Ground Fault Systems

J. Switchboards

K. Panelboards

1.06 TESTING CONSULTANT QUALIFICATIONS

A. All testing shall be performed by an independent TC who is engaged in electrical testing as a major portion of his/her business.

B. The TC shall have field personnel who have successfully demonstrated their knowledge and experience with electrical power distribution systems high voltage and low voltage testing. The TC shall be capable of:

1. Testing, assessing, evaluating, servicing, and reconditioning components.
2. Assuring that the equipment on which work has been performed is safe, reliable and acceptable for its intended purpose.

3. Identifying defective equipment and potential safety problems, environmental hazards, or code violations.
4. Proving a minimum of five (5) years of experience on similar major testing projects.

1.07 TEST INSTRUMENT TRACEABILITY

A. The TC shall have a calibration program which maintains all applicable test instrumentation within rated accuracy.

B. The accuracy shall be traceable to the National Bureau of Standards in an unbroken chain.

C. Instruments shall be calibrated in accordance with the following frequency schedule.

1. Field Instruments: 6 months maximum.
2. Laboratory Instruments: 12 months.
3. Leased Specialty Equipment: 12 months (where accuracy is guaranteed by Lessor, e.g. Doble).

D. Dated calibration labels shall be visible on all test equipment.

E. Records must be kept up-to-date which show date and results of all instruments calibrated or tested.

F. An up-to-date instrument calibration instruction and procedure will be maintained for each test instrument.

PART 2 - PRODUCTS

Not Applicable

PART 3 - EXECUTION

3.01 GENERAL INSPECTION AND CLEANING OF ALL ELECTRICAL EQUIPMENT

A. Inspect for physical damage and abnormal mechanical and electrical conditions.

B. Compare equipment nameplate information with the latest single line diagram and report any discrepancies.

C. Verify proper auxiliary device operation and indicators.

D. Check tightness of accessible bolted electrical joints. Use torque wrench method.

E. Make a close examination of equipment for shipping brackets, insulation, packing, etc. that may not have been removed during original installation.

F. Make a close examination for a collection of dirt or other forms of debris that may have collected in equipment during normal operation.

G. Clean All Equipment:

1. Vacuum inside of case and floor.
2. Vacuum transformer core and coils.

3. Blow out horizontal and vertical ducts with dry nitrogen (maximum pressure of 25 psi).
4. Loosen attached particles and vacuum them away.
5. Wipe all porcelain and other insulating materials with a clean, dry, lint free rag.
6. Clean grooves.
7. Re-vacuum inside surfaces

H. Inspect equipment anchorage.

I. Inspect equipment alignment.

J. Lubricate equipment per manufacturer's recommendations.

3.02 INFRARED SCANNING

A. Inspect the electrical equipment for physical, electrical and mechanical condition.

B. Visually inspect for proper bus alignment.

C. Remove all necessary covers prior to scanning.

D. Scan the following equipment: Switches, bus duct, switchgear, transformers, terminations, cables, cable connection, circuit breakers, and safety switches, etc. This includes all equipment through the secondary switchboard or service.

E. Provide a report indicating the following:

1. Problem area(s) (location of the hot spot(s)).
2. Indicate the temperature rise between the "hot spot(s)" and the normal or reference area.
3. Indicate cause of heat rise.
4. Indicate phase unbalance, if present.
5. Index of areas scanned.
6. Report any problem areas to the Engineer immediately so corrective work may be initiated in a minimum of time.

3.03 GROUNDING SYSTEMS

A. Inspect the ground system for adequate termination at all devices.

B. Perform a fall of potential test per IEEE Standard No. 81, Section 9.03 to determine the ground resistance between the main grounding system and all major electrical equipment frames, system neutral and/or derived neutral points.

C. The main primary service station ground impedance should be no greater than two (2) ohms.

3.04 LIGHTNING/SURGE ARRESTERS

A. Inspect for physical damage. Wipe clean.

B. Perform a ground continuity test to ground system.

C. Perform an insulation resistance test.

D. Perform operational tests as recommended by the device manufacturer.

E. Verify the proper mounting and adequate clearance.

F. Verify the voltage of the units with system one line diagram. Report any discrepancies.

3.05 METERING AND INSTRUMENTATION

A. Examine all devices for broken parts, damage and wire connection tightness.

B. Verify meter connections in accordance with single line meter and relay diagrams.

C. Calibrate all meters at 5 points using full scale test instruments.

D. Calibrate watt-hour meters to one-half percent (0.5%).

E. Verify and/or correct all instrument multipliers.

F. After the meters are calibrated, a calibration curve should be generated which shows the accuracy of the meter throughout the full range. (0 to full scale reading.)

G. Meter selector switches shall be inspected for proper application and operation.

3.06 BATTERY SYSTEMS/UPS

A. Inspect for physical damage and evidence of corrosion. Clean units.

B. Check inter-cell bus link integrity.

C. Measure system charging voltage and each individual cell voltage.

D. Measure the electrolyte specific gravity and level.

E. Measure voltage drop across the individual cells.

F. Perform infrared scan on batteries during discharge and recharge cycles, observing inter-cell connectors, battery links and plates.

G. Verify proper charging rates from charger during recharge mode.

H. Verify individual cell acceptance of charge during recharge mode.

I. Verify and compare measured values with manufacturer's specifications.

3.07 MECHANICAL AND ELECTRICAL INTERLOCK SYSTEMS

A. Physically test each system to insure proper function, operation and sequencing.

B. Closure attempt shall be made on locked open devices.

C. Opening attempt shall be made on locked closed devices.

D. Key exchange shall be made with devices operated in off normal positions.

3.08 DRY TYPE TRANSFORMER

A. Insulation resistance tests shall be performed winding-to-winding and winding-to-ground.

B. A turns ratio test shall be performed between windings at all service tap settings.

C. Over-potential test shall be made on all high and low voltage windings to ground. If factory testing cannot be documented, the CONTRACTOR shall perform applied-voltage and induced-voltage field tests in accordance with IEEE C57.12.01.

D. Winding resistance tests shall be made for each winding at the in-service tap.

E. Test and adjust the cooling fans, controls and alarm functions. Repair, if necessary.

F. Verify that the tap settings/changer is at the desired ratio.

G. Measure secondary voltage phase-to-phase and phase-to-ground after final energization and prior to loading.

H. Verify and/or connect transformer "XO" to ground, load side of "WYE" systems.

3.09 GROUND FAULT SYSTEMS

A. Inspect for physical damage.

B. Inspect the neutral main bonding connection to assure:

1. Zero sequence system is grounded upstream of sensor.
2. Ground strap systems are grounded down stream from the sensing device.
3. Ground connection is made ahead of the neutral disconnect link.

C. Inspect the control power transformer to insure adequate capacity for system.

D. Monitor panels (if present) shall be manually operated for:

1. Trip tests
2. No trip tests
3. Non-automatic reset

E. Zero sequence systems shall be inspected for symmetrical alignment of core balance transformers about all current carrying conductors.

F. Ground fault device circuit nameplate identification shall be verified by device operation.

G. Pickup and time delay settings shall be verified.

H. Insure control circuit has dis-connectable fuse device with current limiting fuses.

I. System neutral insulation resistance shall be measured with the neutral-ground disconnect link removed to insure no shunt ground paths exist. Neutral insulation shall be a minimum 1 MEGOHM.

J. The relay pickup current shall be determined by primary injection at the sensor to operate the circuit interrupting device. Relay pickup current shall be within 10% of device dial, or fixed setting and in no case greater than 1200 amperes.

K. The relay timing shall be tested by injecting 150% and 300% of pickup current into the sensor. Total trip time shall be electrically monitored. Relay timing shall be in accordance with manufacturer's published time-current characteristic curves.

L. System operation shall be tested at 57% of rated voltage.

M. Zone interlock systems shall be simultaneously sensor current injected while monitoring zone blocking function where possible.

3.010 SWITCHBOARDS (LOW VOLTAGE)

A. Visual and Mechanical Inspection:

1. Inspect for physical, electrical and mechanical conditions. Re-torque all bolted connections.
2. Compare equipment nameplate information with latest single line diagram and report discrepancies.
3. Inspect for proper alignment, anchorage and grounding.
4. All doors, panels and sections shall be inspected for paint, dents, scratches, and fit.
5. All active components shall be cleaned where possible and shall be exercised.
6. All indicating devices shall be inspected for proper operation.
7. Inspect in regard to cleanliness and need of lubrication and clean switchboard enclosure using the following methods:
    a. Vacuum inside of switchgear enclosure
    b. Loosen attached particles and vacuum them away.
    c. Wipe all porcelain and other insulating materials with a clean, dry, lint-free rag.
    d. Clean all grooves.
    e. Re-vacuum inside of switchgear enclosure.
    f. Lubricate per manufacturer's recommendations.

B. Electrical Tests:

1. Insulation resistance tests.
2. Measure insulation resistance to each bus section phase-to-phase and phase-to-ground for one (1) minute.
3. Circuit breakers - power type solid state trip:
    a. Contact resistance test shall be performed
    b. Insulation resistance test shall be performed at 1,000 volts DC for 1-minute from pole-to-pole and across open contacts of each phase.

c. Minimum pickup current shall be determined by primary current injection.

d. Long-time delay shall be determined by primary injection of current at 300% pickup current.

e. Short-time pickup and time delay shall be determined by primary injection of current.

f. Instantaneous pickup current shall be determined by injection.

g. Trip unit reset characteristics shall be verified.

h. Adjustments shall be made for final settings in accordance with Engineer's prescribed settings.

i. Auxiliary protective devices such as ground fault or undervoltage relays shall be activated to insure operation of shunt trip devices.

4. Circuit Breakers -- Molded Case:

a. Measure contact resistance.

b. Time-current characteristics test shall be performed by passing 300% rated current through each pole.

c. Trip time shall be determined.

d. Instantaneous pickup current shall be determined by runup or pulse method. Clearing times should be within four cycles or less.

e. Insulation resistance shall be determined pole-to-pole, across interlock systems, and ground fault systems, etc., as they may apply.

3.011 CABLES

A. Visual and Mechanical Inspections:

1. Inspect exposed sections for physical damage.

2. Verify cable is supplied and connected in accordance with single line diagram.

3. Inspect for shield grounding, cable support and termination.

4. If cables are terminated through window type C.T.'s make an inspection to verify that neutrals and grounds are properly terminated for normal operation of protective devices.

5. Inspect for visual jacket and insulation condition.

6. Visible cable bends shall be checked against IPCEA or manufacturer's minimum allowable bending radii -- 12 times the diameter for tape shielded cables.

7. Inspect for proper fireproofing in common cable areas.

B. Electrical Tests -- Above 600 Volts:

1. New cable will be supplied with the cable ends prepared at the factory for an on-reel D.C. Hy-Pot test prior to installation. The new cable will have had standard factory tests. The submittal for cable approval will include the manufacturer's recommendation for the D.C. voltage level to be used for this on-reel testing.

2. Provide four (4) copies of on-reel tests. (For new cables only.)
3. Following completion of all splicing and terminations but prior to connection to equipment, all cable, new and existing, shall have the following tests and inspections performed.
    a. Perform a shield continuity test by OHM meter method. OHMIC value shall be recorded.
    b. Perform D.C. High Potential Test:
        i Each conductor shall be individually tested with other conductors grounded. Shields shall be grounded.
        ii Terminations shall be properly corona suppressed by guard ring, field reduction sphere, or other suitable methods.
        iii DC high potential shall be applied in at least ten equal increments distributed fully over the test voltage range until maximum test voltage is reached. D.C. leakage current shall be recorded at each step after a constant stabilization time (minimum one minute) consistent with system charging current decay. Graphic plot shall be made of leakage current versus voltage at each increment.
        iv After test conductor is raised to the maximum test voltage and maximum leakage current it shall be held for a total of fifteen minutes. Readings of leakage current (Y axis) versus time (X axis) shall be recorded and plotted on 15 second intervals for the first minute and every minute thereafter.
        v At the end of fifteen minutes, turn voltage control to zero and time the voltage decay to 20 percent of test voltage with a stopwatch.
        vi Areas of concern in test results will be high leakage current values, a plot that is other than a reasonably straight line, increase in current during the fifteen minute duration test or a rapid decay in the test voltage following source removal.
        vii Test technician will be responsible for necessary precautions to eliminate losses due to corona and to determine that all points where high potential exists due to tests are properly monitored or isolated during test period to prevent personal or equipment damage.
        viii Maximum test voltage shall be 80% of manufacturer's new cable test voltage for new cable and 60% of manufacturer's new cable test voltage for existing cable. See new cable submittal for allowable test voltages.
        ix In the event the results of the test are not satisfactory the TC shall make such adjustments, changes and replacements as are necessary to correct faults. Following corrections, tests shall be repeated to the extent required to prove the deficiencies are corrected.

C. Electrical Tests -- Below 600 Volts:

1. All secondary cables from the substation transformers to the secondary switchboards shall be subjected to insulation tests using a 500 vdc megger. Resistance shall be one (1) megohm minimum.
2. Visually inspect cables, lugs, connectors and all other components.
3. Check all cable connectors for tightness(with a torque wrench) and clearances.
4. Check for proper grounding resistance at all services and at transformers. Resistance shall be 2 ohms maximum.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement should be made as per-each type of item.

4.02 PAYMENT

B. The cost of complying with each section of this Specification is included in other bid items.

END OF SECTION

PART 1 - GENERAL

1.01 SCOPE

A. Furnish and install a complete electrical metering system as specified herein and as shown on the contract drawings.

1.02 RELATED SPECIFICATIONS

A. Section 16195 – electrical identification

1.03 CODES AND STANDARDS

A. Manufactured according to:

1. IEEE - INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS
2. NEMA - NATIONAL ELECTRICAL MANUFACTURER'S ASSOC.
3. ANSI - AMERICAN NATIONAL STANDARDS INSTITUTE.
4. NEC - NATIONAL ELECTRICAL CODE

1.04 DESIGN CRITERIA

A. Design ambient temperature 60°c.

B. Plant elevation less than 3300 ft.

C. Seismic zone 2a.

1.05 SUBMITTALS -- FOR REVIEW/APPROVAL

A. The following information shall be submitted to the engineer:

B. Master drawing index

C. Front view elevation

D. Single line

E. Schematic diagram

F. Nameplate schedule

G. Component list

H. Assembly ratings including:

I. Voltage rating

J. Continuous current

K. Basic Impulse level

L. Submit six (6) copies of the above information.

1.06 SUBMITTALS -- FOR CLOSEOUT

A. The following information shall be submitted for record purposes:

B. Final as-built drawings and information for items listed in section 1.04

C. Wiring diagrams

D. Certified production test reports

E. Installation information

F. Seismic certification.

G. Submit six (6) copies of the above information.

H. Literature shall reference equipment names, per drawings, that are covered by the manual.

1.07 DELIVERY, STORAGE AND HANDLING

A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

B. Equipment shall be packaged for outdoor storage.

1.08 OPERATION AND MAINTENANCE MANUALS

A. Ten (10) copies of the equipment Operation and Maintenance manuals shall be provided.

B. Operation and Maintenance manuals shall include the following information:

C. Instruction books and/or leaflets

D. Recommended renewal parts list

E. Drawings and information required by section 1.06.

1.09 GUARANTEE

A. Vendor shall guarantee his equipment against faulty material and workmanship for 18 months after shipment or 12 months from time of operating acceptance by OWNER, whichever comes first.

B. Upon notice, the Vendor shall repair or replace in a reasonable period of time, any of his equipment which is faulty.

PART 2 - PRODUCTS

2.01 ELECTRICAL METERING - GENERAL

A. Where indicated on the drawings, provide an Engineer-approved Meter Monitoring (MM) device having the features and functions specified below. The MM shall meet the accuracy portion of ANSI C12.16 Class 10 for revenue metering. The MM shall monitor and display the functions listed below with the accuracy indicated. The MM shall be UL listed, cUL, CSA and CE certified and also meet ANSI standard C37.90.1 for surge withstand.

B. The MM shall monitor and display the functions listed below with the accuracy indicated. The MM shall be UL listed, cUL, CSA and CE certified and also meet ANSI standard C37.90.1 for surge withstand.

C. The MM display shall be NEMA 1, 12, or 3R rated and connected to a separate meter base separate via a standard Category 5 cable. The base shall be capable of being remote panel or DIN-rail mountable or mounting directly to the display. The MM display shall have a 8 digit numeric and 10 alphanumeric character, plus dedicated icons, reverse mode LCD with LED backlight display.

D. All monitored parameters shall be viewable at the display with four button user interface or via network communications. All set points and recorded minimum and maximums shall be stored in non-volatile memory.

E. Metered Values shall be as follows with accuracy in percent of full scale as indicated:

1. AC Phase Voltage and Amperes +/- 0.5%
2. Watts, VA, Vars +/- 1.0%
3. Power Factor +/- 2.0%
4. Frequency +/- 0.1 Hz
5. Watt-hours, VA, VAR-hours +/- 1.0%
6. Watt Demand with 10-, 15-, 20-, 25-, 30-, 45-, 60-minute interval
7. Minimum/Maximum Voltage, Current, Power, Power Factor, Frequency
8. Peak Demand.

    a. The MM shall be supplied with three (3) current transformers sized as required. Potential transformers shall be self-included and fused for up to 600 volts with potential connections suitable for 3-phase 100V, 208/220/240V, 380/416V, 460/575V. Above 600V, provide fused external potential transformers.

    b. The MM control power shall be capable of being supplied from the monitored incoming AC line or supplied from a separate control power source when indicated on the drawings (90 to 600 VAC or 48 to 250 VDC).

    c. A solid-state relay KYZ pulse output shall be provided for use with a watt-hour pulse recorder or totalizer.

    d. Provide communication capability of transmitting data over a compatible two-wire local area network (LAN) to central personal computer for storage and /or printout. The network shall also be capable of transmitting data in RS-232c format via a translator module.

PART 3 - EXECUTION

3.01 FACTORY TESTING

A. Standard factory tests shall be performed on the equipment under this section. All tests shall be in accordance with the latest version of NEMA and UL standards.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement should be made as per each metering equipment item.

4.02 PAYMENT

A. Payment shall be per each metering equipment item.

B. Payment shall include furnishing, installing, transporting, labor, incidental materials, grounding, testing, etc. for a complete installation.

END OF SECTION