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Hensel Phelps / Kiewit Joint Venture
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CMI - M.C. Dean - Brittingham & Associates

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SECTION 16050
BASIC ELECTRICAL MATERIALS AND METHODS
07/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D 709	(2001) Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2005) National Electrical Safety Code
IEEE C57.12.28	(2005) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.29	(1999) Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments
IEEE Std 100	(2000) The Authoritave Dictionary of IEEE Standards Terms

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2003) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2005; TIA 2005) National Electrical Code

1.2 RELATED REQUIREMENTS

This section applies to certain sections of Division 02, EXISTING CONDITIONS Division 11, EQUIPMENT, Division 13, SPECIAL CONSTRUCTION, and Division 15, PLUMBING and HEATING VENTILATING AND AIR CONDITIONING. This section applies to all sections of Division 16, ELECTRICAL and UTILITIES, of this project specification unless specified otherwise in the individual sections. This section has been incorporated into, and thus, does not apply to, and is not referenced in the following sections.

Section 16272 THREE-PHASE PAD MOUNTED TRANSFORMERS
Section 16360 SECONDARY UNIT SUBSTATIONS
Section 16402 INTERIOR DISTRIBUTION SYSTEM
Section 16510 INTERIOR LIGHTING

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE Std 100.

b. The technical sections referred to herein are those specification sections that describe products, installation procedures, and equipment operations and that refer to this section for detailed description of submittal types.

c. The technical paragraphs referred to herein are those paragraphs in PART 2 - PRODUCTS and PART 3 - EXECUTION of the technical sections that describe products, systems, installation procedures, equipment, and test methods.

1.4 ELECTRICAL CHARACTERISTICS

Electrical characteristics for this project shall be 12.47 kV primary, three phase, three wire, 60 Hz, and 480 volts secondary, three phase, four wire. Final connections to the power distribution system at the existing substation shall be made by the Contractor as directed by the Contracting Officer.

1.5 ADDITIONAL SUBMITTALS INFORMATION

Submittals required in other sections that refer to this section must conform to the following additional requirements as applicable.

1.5.1 Shop Drawings (SD-02)

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices.

1.5.2 Product Data (SD-03)

Submittal shall include performance and characteristic curves.

1.6 QUALITY ASSURANCE

1.6.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.6.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in the technical section.

1.6.2.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.6.2.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.7 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract. The warranty periodshall be one year from successful completion of commissioning. Critical systems (UPS and cable repair) shall have a response tome of 4 hours after notification. non critcal sytems shal have a response time of 18 hours after notifiation. The response team shall notify the Facilities Control Center upon arrival at the site and immediately initiate appropriate coretive ation at the notifcation and the reciept of instuctions.

1.8 POSTED OPERATING INSTRUCTIONS

Provide for each system and principal item of equipment as specified in the technical sections for use by operation and maintenance personnel. The operating instructions shall include the following:

a. Wiring diagrams, control diagrams, and control sequence for each principal system and item of equipment.

b. Start up, proper adjustment, operating, lubrication, and shutdown procedures.

c. Safety precautions.

d. The procedure in the event of equipment failure.

e. Other items of instruction as recommended by the manufacturer of each system or item of equipment.

Print or engrave operating instructions and frame under glass or in approved laminated plastic. Post instructions where directed. For operating instructions exposed to the weather, provide weather-resistant materials or weatherproof enclosures. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal or peeling.

1.9 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

1.10 FIELD FABRICATED NAMEPLATES

ASTM D 709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified in the technical sections or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 0.125 inch thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be one by 2.5 inches. Lettering shall be a minimum of 0.25 inch high normal block style.

1.11 WARNING SIGNS

Provide warning signs for the enclosures of electrical equipment including substations, pad-mounted transformers, pad-mounted switches, generators, and switchgear having a nominal rating exceeding 600 volts. Signage for warnings notification, etcetera shall be baked enamel, pre-printed aluminium.

a. When the enclosure integrity of such equipment is specified to be in accordance with IEEE C57.12.28 or IEEE C57.12.29, such as for pad-mounted transformers, provide self-adhesive warning signs on the outside of the high voltage compartment door(s). Sign shall be a decal and shall have nominal dimensions of 7 by 10 inches with the legend "DANGER HIGH VOLTAGE" printed in two lines of nominal 2 inch high letters. The word "DANGER" shall be in white letters on a red background and the words "HIGH VOLTAGE" shall be in black letters on a white background. Decal shall be Panduit No. PPSO710D72 or approved equal.

b. Electrical rooms containint equipemnts operating at 600 Volts and above shall be provided with self-adhesive warning signs on the door(s). Sign shall be a decal and shall have nominal dimensions of 7 by 10 inches with the legend "DANGER HIGH VOLTAGE" printed in three lines of nominal 2 inch high letters. The word "DANGER" shall be in white letters on a red background and the words "HIGH VOLTAGE" shall be in black letters on a white background. The thrid line shall contain the words "Qualified Personal ONLY." in 1" black letters on a white background. Decal shall be Panduit No. PPSO710D72 or approved equal.

1.12 ELECTRICAL REQUIREMENTS

Electrical installations shall conform to IEEE C2, NFPA 70, and requirements specified herein.

1.13 INSTRUCTION TO GOVERNMENT PERSONNEL

Where specified in the technical sections, furnish the services of competent instructors to give full instruction to designated Government personnel in the adjustment, operation, and maintenance of the specified systems and equipment, including pertinent safety requirements as required. Instructors shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work. Instruction shall be given during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. The number of man-days (8 hours per day) of instruction furnished shall be as specified in the individual section.

PART 2 PRODUCTS

2.1 FACTORY APPLIED FINISH

Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test and the additional requirements specified in the technical sections.

2.2 Manufactures Instructions

All electrical products shall be installed according to the manufactures instructions.

PART 3 EXECUTION

3.1 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting shall be as specified in Section 09900 PAINTS AND COATINGS.

3.2 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.3 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side, but space the signs a maximum of 30 feet apart.

-- End of Section --

SECTION 16070
SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT
04/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

BUILDING CODES

International Building Code (IBC) IBC 2003

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 325 (2005 e13) Steel Construction Manual ASTM INTERNATIONAL (ASTM)

ASTM E 580 (2002e1) Application of Ceiling Suspension Systems for Acoustical Tile and Lay-In

Panels in Areas Requiring Moderate Seismic Restraint

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-03A (2005) Seismic Design for Buildings

UNDERWRITERS LABORATORIES (UL)

UL 1598 (2004) Luminaires

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Lighting Fixtures in Buildings; G
Equipment Requirements; G

Detail drawings along with catalog cuts, templates, and erection and installation details, as appropriate, for the items listed. Submittals shall be complete in detail; shall indicate thickness, type, grade, class of metal, and dimensions; and shall show construction details, reinforcement, anchorage, and installation with relation to the building construction.

SD-03 Product Data

Lighting Fixtures in Buildings; G

Equipment Requirements; G

Copies of the design calculations with the detail drawings. Calculations shall be stamped by a registered engineer and shall verify the capability of structural members to which bracing is attached for carrying the load from the brace.

Contractor Designed Bracing; G

Copies of the Design Calculations with the Drawings. Calculations shall be approved, certified, stamped and signed by a Registered Professional Engineer. Calculations shall verify the capability of structural members to which bracing is attached for carrying the load from the brace.

1.3 SYSTEM DESCRIPTION

1.3.1 General Requirements

The requirements for seismic protection measures described in this section shall be applied to the electrical equipment and systems listed below. Structural requirements shall be in accordance with Section 13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT.

1.3.2 Electrical Equipment

Electrical equipment shall include the following items to the extent required on the drawings or in other sections of this specifications:

Control Panels Air Handling Units
Pumps with Motors Power Distribution Units (PDU)
Light Fixtures Unit Substations
Motor Control Centers Transformers
Switchboards (Floor Mounted) Switchgear, Medium & Low Voltage
Uninterruptible Power System (UPS) Life Safety Inverters
Cable Trays Cable Bus
Conduit (Life Safety associated) Battery Racks
Engine-Generator Sets Fuel Day Tanks
Panelboards

1.3.3 Electrical Systems

The following electrical systems shall be installed as required on the drawings and other sections of this specification and shall be seismically protected in accordance with this specification:

Power Systems Life Safety Power Systems
UPS Fire Alarm Systems
Communications Systems Data Systems
SCADA Systems

1.3.4 Contractor Designed Bracing

The Contractor shall design the bracing in accordance with UFC 3-310-03A and additional data furnished by the Contracting Officer. Resistance to lateral forces induced by earthquakes shall be accomplished without consideration of friction resulting from gravity loads. UFC 3-310-03A uses parameters for the building, not for the equipment in the building;

therefore, corresponding adjustments to the formulas shall be required. Loadings determined using UFC 3-310-03A are based on strength design; therefore, AISC 325 shall be used for the design. The bracing for the following electrical equipment and systems shall be developed by the Contractor:

Control Panels Pumps with Motors
Lighting Fixtures Motor Control Centers
Switchboards UPS
Switchgear, Medium & Low Voltage Unit Substations
Transformers Battery Racks
Engine Generator Sets Busway
Fire Alarm Control Panels Motor Controllers
Variable Frequency Drives Power Distribution Units
Normal Power Systems Cable Trays
Conduits Life Safety Power System
Inverter System Standby Power System
SCADA System Communications System
Fire Alarm System

1.3.5 Conduits Requiring No Special Seismic Restraints

Seismic restraints may be omitted from electrical conduit less than 2-1/2 inches trade size and individually supported or supported no more then 12 inches from a structural member, wall, or the floor above.. All other interior conduit, shall be seismically protected as specified.

1.4 EQUIPMENT REQUIREMENTS

1.4.1 Rigidly Mounted Equipment

The following specific items of equipment: Rigidly-mounted electrical equipment to be furnished under this contract shall be constructed and assembled to withstand the seismic forces specified in UFC 3-310-03A, Chapter 10. Each item of rigid electrical equipment shall be entirely located and rigidly attached on one side only of a building expansion joint. Piping, electrical conduit, etc., which cross the expansion joint shall be provided with flexible joints that are capable of accommodating displacements equal to the full width of the joint in both orthogonal directions.

Mounted on vibration isolators
Substations
Transformers
Switch Boards and Switch Gears
Motor Control Centers
Free Standing Electric Motors
UPS
PDU
Battery Racks
Daytanks

1.4.2 Nonrigid or Flexibly-Mounted Equipment

The following specific items of equipment to be furnished: Packaged Engine-Generator Sets Flexibly-mounted electrical equipment shall be constructed and assembled to resist a horizontal lateral force of 2.0 times the operating weight of the equipment at the vertical center of gravity of the equipment and horizontally constrained.

PART 2 PRODUCTS

2.1 LIGHTING FIXTURE SUPPORTS

Lighting fixtures and supports shall conform to UL 1598.

2.2 SWAY BRACING MATERIALS

Sway bracing materials (e.g. rods, plates, rope, angles, etc.) shall be as specified in Section 13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT.

PART 3 EXECUTION

3.1 SWAY BRACES FOR CONDUIT

Conduit shall be braced as for an equivalent weight pipe in accordance with Section 15070 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT.

3.2 LIGHTING FIXTURES IN BUILDINGS

Lighting fixtures and supports shall conform to the following:

3.2.1 Pendant Fixtures

Pendant fixtures shall conform to the requirements of UFC 3-310-03A, Chapter 10.

3.2.2 Ceiling Attached Fixtures

3.2.2.1 Recessed Fluorescent Fixtures

Recessed fluorescent individual or continuous-row mounted fixtures shall be supported by a seismic-resistant suspended ceiling support system built in accordance with ASTM E 580. Seismic protection for the fixtures shall conform to the requirements of UFC 3-310-03A, Chapter 10. Recessed lighting fixtures not over 56 pounds in weight may be supported by and attached directly to the ceiling system runners using screws or bolts, number and size as required by the seismic design. Fixture accessories, including louvers, diffusers, and lenses shall have lock or screw attachments.

3.2.2.2 Surface-Mounted Fluorescent Fixtures

Surface-mounted fluorescent individual or continuous-row fixtures shall be attached to a seismic-resistant ceiling support system built in accordance with ASTM E 580. Seismic protection for the fixtures shall conform to the requirements of UFC 3-310-03A, Chapter 10.

3.2.3 Assembly Mounted on Outlet Box

A supporting assembly, that is intended to be mounted on an outlet box, shall be designed to accommodate mounting features on 4 inch boxes, plaster rings, and fixture studs.

3.2.4 Wall-Mounted Emergency Light Unit

Attachments for wall-mounted emergency light units shall be designed and secured for the worst expected seismic disturbance at the site.

3.2.5 Lateral Force

Structural requirements for light fixture bracing shall be in accordance with Section 13080 SEISMIC PROTECTION FOR MISCELLANIOUS EQUIPMENT.

-- End of Section --

SECTION 16081
APPARATUS INSPECTION AND TESTING
04/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS (2003) Acceptance Testing Specifications

1.2 RELATED REQUIREMENTS

Section 16050 BASIC ELECTRICAL MATERIALS AND METHODS applies to this section with additions and modifications specified herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-06 Test Reports
Acceptance tests and inspections; G
SD-07 Certificates
Qualifications of organization, and lead engineering technician; G
Acceptance test and inspections procedure; G

1.4 QUALITY ASSURANCE

1.4.1 Qualifications

Contractor shall engage the services of a qualified testing organization to provide inspection, testing, calibration, and adjustment of the electrical distribution system and generation equipment listed in paragraph entitled "Acceptance Tests and Inspections" herein. Organization shall be independent of the supplier, manufacturer, and installer of the equipment. The organization shall be a first tier subcontractor. No work required by this section of the specification shall be performed by a second tier subcontractor.

a. Submit name and qualifications of organization. Organization shall have been regularly engaged in the testing of electrical materials, devices, installations, and systems for a minimum of 5 years. The organization shall have a calibration program, and test instruments used shall be calibrated in accordance with NETA ATS.

b. Submit name and qualifications of the lead engineering technician performing the required testing services. Include a list of three comparable jobs performed by the technician with specific names and telephone numbers for reference. Testing, inspection, calibration, and adjustments shall be performed by an engineering technician, certified by NETA or the National Institute for Certification in Engineering Technologies (NICET) with a minimum of 5 years' experience inspecting, testing, and calibrating electrical distribution and generation equipment, systems, and devices.

1.4.2 Acceptance Tests and Inspections Reports

Submit certified copies of inspection reports and test reports. Reports shall include certification of compliance with specified requirements, identify deficiencies, and recommend corrective action when appropriate. Type and neatly bind test reports to form a part of the final record. Submit test reports documenting the results of each test not more than 10 days after test is completed.

1.4.3 Acceptance Test and Inspections Procedure

Submit test procedure reports for each item of equipment to be field tested at least 45 days prior to planned testing date. Do not perform testing until after test procedure has been approved.

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION

3.1 ACCEPTANCE TESTS AND INSPECTIONS

Testing organization shall perform acceptance tests and inspections. Test methods, procedures, and test values shall be performed and evaluated in accordance with NETA ATS, the manufacturer's recommendations, and paragraph entitled "Field Quality Control" of each applicable specification section. Tests identified as optional in NETA ATS are not required unless otherwise specified. Equipment shall be placed in service only after completion of required tests and evaluation of the test results have been completed. Contractor shall supply to the testing organization complete sets of shop drawings, settings of adjustable devices, and other information necessary for an accurate test and inspection of the system prior to the performance of any final testing. Contracting Officer shall be notified at least 14 days in advance of when tests will be conducted by the testing organization. Perform acceptance tests and inspections on applicable equipment and systems specified in the following sections:

a. Section 16263 DIESEL-GENERATOR SET STATIONARY 100-2800 KW, WITH AUXILIARIES. Functional engine shutdown tests, vibration base-line test, and load bank test shall not be performed by the testing organization. These tests shall be performed by the start-up engineer.

b. Section 16272 THREE-PHASE PAD-MOUNTED TRANSFORMERS

c. Section 16302 UNDERGROUND TRANSMISSION AND DISTRIBUTION

d. Section 16360 SECONDARY UNIT SUBSTATIONS

e. Section 16410 AUTOMATIC TRANSFER SWITCHES

f. Section 16442 SWITCHBOARDS AND SWITCHGEAR

3.2 SYSTEM ACCEPTANCE

Final acceptance of the system is contingent upon satisfactory completion of acceptance tests and inspections.

3.3 PLACING EQUIPMENT IN SERVICE

A representative of the approved testing organization shall be present when equipment tested by the organization is initially energized and placed in service.

-- End of Section --

SECTION 16263
DIESEL-GENERATOR SET STATIONARY 100-2800 KW, WITH AUXILIARIES
04/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.11 (1987) Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV)

ASME INTERNATIONAL (ASME)

ASME B16.11 (2005) Forged Fittings, Socket-Welding and Threaded

ASME B16.3 (1998) Malleable Iron Threaded Fittings

ASME B16.5 (2003) Pipe Flanges and Flanged Fittings

ASME B31.1 (2004) Power Piping

ASME BPVC SEC IX (2004) Boiler and Pressure Vessel Code; Section IX, Welding and Brazing

Qualifications

ASME BPVC SEC VIII D1 (2004) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage

ASTM INTERNATIONAL (ASTM)

ASTM A 106/A 106M (2004b) Seamless Carbon Steel Pipe for High-Temperature Service

ASTM A 181/A 181M (2001) Carbon Steel Forgings, for General-Purpose Piping

ASTM A 234/A 234M (2005) Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service

ASTM A 53/A 53M (2004a) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

ASTM D 975 (2004be1) Diesel Fuel Oils

ELECTRICAL GENERATING SYSTEMS ASSOCIATION (EGSA)

EGSA 101P	(1995) Engine Driven Generator Sets

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2005) National Electrical Safety Code
IEEE C27.20.1	
IEEE C57.13.1	(1981) Guide for Field Testing of Relaying Current Transformers
IEEE Std 1	(2000) General Principles for Temperature Limits in the Rating of Electric Equipment and for the Evaluation of Electrical Insulation
IEEE Std 100	(2000) The Authoritave Dictionary of IEEE Standards Terms
IEEE Std 115	(1995; R 2002) Test Procedures for Synchronous Machines: Part I: Acceptance and Performance Testing; Part II: Test Procedures and Parameter Determination for Dynamic Analysis
IEEE Std 120	(1989) Master Test Guide for Electrical Measurements in Power Circuits
IEEE Std 404	(2000) Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V Through 500 000 V
IEEE Std 43	(2000) Testing Insulation Resistance of Rotating Machinery
IEEE Std 48	(1996; R 2003) Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5 kV through 765 kV
IEEE Std 484	(2002) Recommended Practice for Installation Design and Implementation of Vented Lead-Acid Batteries for Stationary Applications
IEEE Std 485	(1997) Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications
IEEE Std 519	(1992) Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
IEEE Std 81	(1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (Part 1)Normal Measurements

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2002) Pipe Hangers and Supports - Materials, Design and Manufacture
MSS SP-69	(2002) Pipe Hangers and Supports - Selection and Application
MSS SP-80	(2003) Bronze Gate, Globe, Angle and Check Valves

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2	(1996; R 2004) Standard for Industrial Control and Systems: Controllers, Contractors, and Overload Relays Rated Not More than 2000 Volts AC or 750 Volts DC: Part 8 - Disconnect Devices for Use in Industrial Control Equipment
NEMA ICS 6	(1993; R 2001) Industrial Control and Systems: Enclosures
NEMA MG 1	(2003; R 2004) Motors and Generators
NEMA PB 1	(2000) Panelboards
NEMA SG 6	(2000) Power Switching Equipment
NEMA WC 74	(2000) 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 110	(2005) Emergency and Standby Power Systems
NFPA 30	(2003) Flammable and Combustible Liquids Code
NFPA 37	(2002) Installation and Use of Stationary Combustion Engines and Gas Turbines
NFPA 70	(2005) National Electrical Code
NFPA 99	(2005) Health Care Facilities

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J537	(2000) Storage Batteries

UNDERWRITERS LABORATORIES (UL)

UL 1236	(2002) Battery Chargers for Charging Engine-Starter Batteries

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detailed Drawings

Detailed drawings, as specified.

Acceptance; G

Drawings which accurately depict the as-built configuration of the installation, upon acceptance of the diesel-generator set installation. Layout drawings shall be revised to reflect the as-built conditions and shall be submitted with the as-built drawings.

SD-03 Product Data

Sound Limitations; G

Sound power level data for the packaged unit operating at 100% load in a free field environment. The data should demonstrate compliance with the sound limitation requirements of this specification.

Harmonic Requirements; G

Engine-Generator Parameter Schedule

Description of the generator features which mitigate the effects of the non-linear loads listed.

Day Tank

Calculations for the capacity of each day tank, including allowances for recirculated fuel, usable tank capacity, and duration of fuel supply.

Power Factor

The generator capability curve showing generator kVA output capability (kW vs. kvar) for both leading and lagging power factors ranging from 0 to 1.0.

Heat Exchanger

Manufacturers data to quantify heat rejected to the space with the engine generator set at rated capacity.

Cooling System

A letter which certifies that the engine-generator set and cooling system function properly in the ambient temperature specified, stating the following values:

a. The maximum allowable inlet temperature of the coolant fluid.

b. The minimum allowable inlet temperature of the coolant fluid.

c. The maximum allowable temperature rise in the coolant fluid through the engine.

Time-Delay on Alarms

The magnitude of monitored values which define alarm or action set points, and the tolerance (plus and/or minus) at which the devices activate the alarm or action for items contained within the alarm panels.

Generator

Manufacturer's standard data for each generator (prototype data at the specified rating or above is acceptable), listing the following information:

a. rect-Axis subtransient reactance (per unit).

b. The generator kW rating and short circuit current capacity (both symmetric and asymmetric).

Manufacturer's Catalog

Manufacturer's standard catalog data describing and depicting each engine-generator set and all ancillary equipment in sufficient detail to demonstrate complete specification compliance.

Site Welding

A copy of qualifying procedures and a list of names and identification symbols of qualified welders and welding operators. A letter listing the welder qualifying procedures for each welder, complete with supporting data such as test procedures
used, what was tested to, and a list of the names of all welders and their identification symbols.

Spare Parts

List of spare parts, as specified.

Onsite Training

A letter giving the date proposed for conducting the onsite training course, the agenda of instruction, a description of the video taping service to be provided, and the kind and quality of the tape to be left with the Contracting Officer at the end of the instructional period.

Battery Charger

Battery charger sizing calculations.

Vibration-Isolation

Vibration isolation system performance data for the range of frequencies generated by the engine-generator set during operation from no load to full load and the maximum vibration transmitted to the floor. Description of seismic qualification of the engine-generator mounting, base, and vibration isolation.

Posted Data and Instructions; G

Posted data including wiring and control diagrams showing the key mechanical and electrical control elements, and a complete layout of the entire system.

Instructions

Instructions including: the manufacturers pre-start checklist and precautions; startup procedures for test-mode, manual-start mode, and automatic-start mode (as applicable); running checks, procedures, and precautions; and shutdown procedures, checks, and precautions. Instructions shall include procedures for interrelated equipment (such as heat recovery systems, co-generation, load-shedding, and automatic transfer switches). Instructions shall be weatherproof, laminated in plastic, and posted where directed.

Experience

Statement showing that each component manufacturer has a minimum of 3 years experience in the manufacture, assembly and sale of components used with stationary diesel engine-generator sets for commercial and industrial use. The engine-generator set manufacturer/assembler has a minimum of 3 years experience in the manufacture, assembly and sale of stationary diesel engine-generator sets for commercial and industrial use.

Field Engineer

A letter listing the qualifications, schools, formal training, and experience of the field engineer.

General Installation

A copy of the manufacturer's installation procedures and a detailed description of the manufacturer's recommended break-in procedure.

SD-06 Test Reports

Factory Inspection and Tests

Six complete reproducible copies of the factory inspection result on the checklist format specified in paragraph FACTORY INSPECTION AND TESTS.

Factory Tests

a. A letter giving notice of the proposed dates of factory inspections and tests at least 14 days prior to beginning tests.

b. A detailed description of the manufacturer's procedures for factory tests at least 14 days prior to beginning tests.

11 inch binders having a minimum of 3 rings from which material may readily be removed and replaced, including a separate section
for each test. Sections shall be separated by heavy plastic dividers with tabs. Data plots shall be full size (8-1/2 x 11 inch
minimum), showing grid lines, with full resolution.

(1) A detailed description of the procedures for factory tests.

(2) A list of equipment used, with calibration certifications.

(3) A copy of measurements taken, with required plots and graphs.

(4) The date of testing.

(5) A list of the parameters verified.

(6) The condition specified for the parameter.

(7) The test results, signed and dated.

(8) A description of adjustments made.

Onsite Inspection and Tests; G

a. A letter giving notice of the proposed dates of onsite inspections and tests at least 14 days prior to beginning tests.

b. A detailed description of the Contractor's procedures for onsite tests including the test plan and a listing of equipment necessary to perform the tests. Submission shall be at least 14 days prior to beginning tests.

c. Six copies of the onsite test data described below in 8-1/2 x 11 inch binders having a minimum of 3 rings from which material may readily be removed and replaced, including a separate section
for each test. Sections shall be separated by heavy plastic dividers with tabs. Data plots shall be full size (8-1/2 x 11 inch
minimum), showing grid lines, with full resolution.

(1) A detailed description of the procedures for onsite tests.

(2) A list of equipment used, with calibration certifications.

(3) A copy of measurements taken, with required plots and graphs.

(4)The date of testing.

(5)A list of the parameters verified.

(6)The condition specified for the parameter.

(7)The test results, signed and dated.

(8) A description of adjustments made.

SD-07 Certificates

Vibration Isolation

Torsional analysis including prototype testing or and calculations which certify and demonstrate that no damaging or dangerous torsional vibrations will occur when the prime mover is connected to the generator, at synchronous speeds, + 10%.

Prototype Test

Manufacturer's standard certification that prototype tests were performed for the generator model proposed.

Reliability and Durability

A reliability and durability certification letter from the manufacturer and assembler to prove that existing facilities are and have been successfully utilizing the same components proposedto meet this specification, in similar service. Certification maybe based on components, i.e. engines used with different models ofgenerators and generators used with different engines, and doesnot exclude annual technological improvements made by amanufacturer in the basic standard-model component on whichexperience was obtained, provided parts interchangeability has notbeen substantially affected and the current standard model meetsthe performance requirements specified. Provide a list with thename of the installations, completion dates, and name andtelephone number of a point of contact.

Emissions

A certification from the engine manufacturer stating that the engine exhaust emissions meet the federal, state, and local regulations and restrictions specified. At a minimum this certification shall include emission factors for criteria pollutants including nitrogen oxides, carbon monoxide, particulate matter, sulfur dioxide, non-methane hydrocarbon, and for hazardous air pollutants (HPAs).

Sound Limitations

A certification from the manufacturer stating that the sound emissions meet the specification.

Site Visit

A letter stating the date the site was visited and listing discrepancies found.

Current Balance

A certification stating that the flywheel has been statically and dynamically balanced and is capable of being rotated at 125% of rated speed without vibration or damage.

Materials and Equipment

A certification stating that where materials or equipment are specified to comply with requirements of UL, written proof of such compliance has been obtained. The label or listing of the specified agency, or a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency are acceptable as proof.

Inspections

A letter certifying that all facilities are complete and functional; that each system is fully functional; and that each item of equipment is complete, free from damage, adjusted, and ready for beneficial use.

Cooling System

Certification that the engine-generator set and cooling system function properly in the ambient temperatures specified.

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G

Six copies of the operation manual (approved prior to commencing onsite tests) in 8-1/2 x 11 inch binders, having a minimum of 3 rings from which material may readily be removed and replaced, including a separate section for each system or subsystem. Sections shall be separated by heavy plastic dividers with tabs which identify the material in the section. Drawings shall be folded blue lines, with the title block visible, and placed in 8-1/2 x 11 inch plastic pockets with reinforced holes. One full size reproducible mylar of each drawing shall accompany the booklets. Mylars shall be rolled and placed in a heavy cardboard tube with threaded caps on each end. Two complete electronic copies of the documentation shall be submitted along with the required manual and drawings. The drawings shall be submitted in both pdf and autocad drawing formats. The manual shall include: step-by-step procedures for system startup, operation, and shutdown; drawings, diagrams, and single-line schematics to illustrate and define the electrical, mechanical, and hydraulic systems together with their controls, alarms, and safety systems; the manufacturer's name, model number, and a description of equipment in the system. The instructions shall include procedures for interface and interaction with related systems to include automatic transfer, switchgear, load sharing, synchronizing, isolated and infinite bus configurations, load shedding systems, and uninterruptible power supplies. Each booklet shall include a CDROM containing an ASCII file and PDF file of the procedures.

Maintenance Procedures; G

Six copies of the maintenance manual containing the information described below in 8-1/2 x 11 inch binders having a minimum of three rings from which material may readily be removed and replaced, including a separate section for each item listed. Each section shall be separated by a heavy plastic divider with tabs.

Drawings shall be folded, with the title block visible, and placed in plastic pockets with reinforced holes.

a. Procedures for each routine maintenance item.
Procedures for troubleshooting.

Factory-service, take-down overhaul, and repair service manuals, with parts lists.

b. A copy of the posted instructions.

c. A component list which includes the manufacturer's name, address, type or style, model or serial number, rating, and catalog number for the major components specified for nameplates. Six complete reproducible copies of the final relay and protective device settings. The settings shall be recorded with the name of the company and individual responsible for their accuracy.

Special Tools

Two complete sets of special tools required for maintenance (except for electronic governor handset). Special tools are those that only the manufacturer provides, for special purposes, or to reach otherwise inaccessible parts. The tools shall be supplied complete with a suitable tool box. One handset shall be provided for each electronic governor when required to indicate and/or change governor response settings.

Filters

Two complete sets of filters, required for maintenance, shall be supplied in a suitable storage box. These filters shall be in addition to filters replaced after testing.

1.3 SYSTEM DESCRIPTION

Each engine-generator set shall be provided and installed complete and totally functional, with all necessary ancillary equipment to include: air filtration; starting system; generator controls, protection, and isolation; instrumentation; lubrication; fuel system; cooling system; and engine exhaust system. Each engine-generator set shall satisfy the requirements specified in the Engine-Generator Parameter Schedule.

1.3.1 Engine-Generator Parameter Schedule

ENGINE-GENERATOR PARAMETER SCHEDULE

Power Rating	Generator plant shall be capable of continuous operation of 19,000 kW plant load for 168 hours at a time with one machine out-of-service (system shall be expandable to provide 24,000 kW).
Power Factor	0.8 lagging to 1.0 lagging

ENGINE-GENERATOR PARAMETER SCHEDULE

Engine-Generator Applications	parallel with other generators on an isolated bus and utility bus (two scenarios)
Maximum Speed	1800 rpm
Heat Exchanger Type	fin-tube (radiator)
Governor Type	Droop
Frequency Regulation	(droop) 3% (maximum)
(No Load to Full Load) Frequency Bandwidth	+ 0.4%
(steady state)] Voltage Regulation	+ 2% (maximum)
(No Load to Full Load) (Stand alone applications) Voltage Bandwidth (steady state)	+ 0.5%
Frequency	60 Hz
Voltage	15,000 volts rated, operated at 12,470 volts
Phases	3 Phase, Wye
Minimum Generator	12 %
Subtransient	Reactance
Max Step Load Increase	100% of Service Load at 0.8 PF
Transient Recovery Time with Step Load Increase (Voltage)	36 seconds
Transient Recovery Time with Step Load Increase (Frequency)	33 seconds
Maximum Voltage Deviation with Step Load Increase voltage	22.7% of rated
Maximum Frequency Deviation	7% of rated
with Step Load Increase	frequency
Max Step Load Decrease (without shutdown)	100% of Service Load at 0.8 PF
Max Time to Start and be Ready to Assume Load	6 seconds
Max Summer Indoor Temp (Prior to Genset Operation)	104 degrees F

ENGINE-GENERATOR PARAMETER SCHEDULE

Min Winter Indoor Temp 50 degrees F
(Prior to Genset Operation)

Installation Elevation 1000 feet above sea level

1.3.2 Rated Output Capacity

Each engine-generator-set shall provide power equal to the sum of Service Load plus the machine's efficiency loss and associated ancillary equipment loads. Rated output capacity shall also consider engine and/or generator oversizing required to meet requirements in paragraph Engine-Generator Parameter Schedule.

1.3.3 Power Ratings

Power ratings shall be in accordance with EGSA 101P.

1.3.4 Transient Response

The engine-generator set governor and voltage regulator shall cause the engine-generator set to respond to the maximum step load changes such that output voltage and frequency recover to and stabilize within the operational bandwidth within the transient recovery time. The engine-generator set shall respond to maximum step load changes such that the maximum voltage and frequency deviations from bandwidth are not exceeded.

1.3.5 Reliability and Durability

Each prime engine-generator set shall have both an engine and a generator capable of delivering the specified power on a prime basis with an anticipated mean time between overhauls of not less than 10,000 hours operating with a 70% load factor. Two like engines and two like generators shall be cited that have performed satisfactorily in a stationary power plant, independent from the physical location of the manufacturer's and assembler's facilities. The engine and generators should have been in operation for a minimum of 8000 actual hours at a minimum load of 70% of the rated output capacity. During two consecutive years of service, the units should not have experienced any failure resulting in a downtime in excess of 72 hours. Like engines shall be of the same model, speed, bore, stroke, number and configuration of cylinders and rated output capacity. Like generators shall be of the same model, speed, pitch, cooling, exciter, voltage regulator and rated output capacity.

1.4 GENERAL REQUIREMENTS

1.4.1 Engine-Generator Set

Each set shall consist of one engine, one generator, and one exciter mounted, assembled, and aligned on one base; and other necessary ancillary equipment which may be mounted separately. Sets having a capacity of 750 kW or smaller shall be assembled and attached to the base prior to shipping. Sets over 750 kW capacity may be shipped in sections. Each set component shall be environmentally suitable for the location shown and shall be the manufacturer's standard product offered in catalogs for commercial or industrial use. Any nonstandard products or components and the reason for their use shall be specifically identified in paragraph SUBMITTALS.

1.4.2 Nameplates

Each major component of this specification shall have the manufacturer's name, type or style, model or serial number and rating on a plate secured to the equipment. As a minimum, nameplates shall be provided for:

Engines Relays
Generators Transformers (CT & PT)
Regulators Day tanks
Pumps and pump motors Governors
Generator Breaker Air Starting System
Economizers Heat exchangers (other than base mounted)
Battery charger Heaters
Switchboards Exhaust mufflers
Switchgear Silencers
Battery Exciters

1.4.3 Personnel Safety Devices

Exposed moving parts, parts that produce high operating temperatures, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. The safety devices shall be installed so that proper operation of the equipment is not impaired.

1.4.4 Site Visit

Before performing any work, the premises shall be visited and all details of the work verified. The Contracting Officer shall be advised in writing of any discrepancies.

1.4.5 Conformance to Codes and Standards

Where equipment is specified to conform to requirements of any code or standard such as UL, NEMA, etc., the design, fabrication and installation shall also conform to the code.

1.4.6 Site Welding

Structural members shall be welded in accordance with Section 05090 WELDING, STRUCTURAL. For all other welding, procedures and welders shall be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by a previously qualified employer may be accepted as permitted by ASME B31.1. Welder qualification tests shall be performed for each welder whose qualifications are not in compliance with the referenced standards. The Contracting Officer shall be notified 24 hours in advance of qualification tests. The qualification tests shall be performed at the work site if practical. The welder or welding operator shall apply his assigned symbol near each weld he makes as a permanent record.

1.4.7 Parallel Operation

Each engine-generator set specified for parallel operation shall be configured for automatic and manual parallel operation. Each set shall be capable of parallel operation with a commercial power source on an infinite bus and one or more sets on an isolated bus.

1.4.8 Load Sharing

Each engine-generator set specified for parallel operation shall be configured to automatically load share with other sets by proportional loading. Proportional loading shall load each set to within 5% of its fair share. A set's fair share is its nameplate-rated capacity times the total load, divided by the sum of all nameplate-rated capacities of on-line sets. Load sharing shall incorporate both the real and reactive components of the load.

1.4.9 Engine-Generator Set Enclosure

The engine-generator set enclosure shall be corrosion resistant and fully weather resistant. The enclosure shall contain all set components and provide ventilation to permit operation at Service Load under secured conditions. Doors shall be provided for access to controls and equipment requiring periodic maintenance or adjustment. Removable panels shall be provided for access to components requiring periodic replacement. The enclosure shall be capable of being removed without disassembly of the engine-generator set or removal of components other than the exhaust system. The enclosure shall reduce the noise of the generator set to within the limits specified in the paragraph SOUND LIMITATIONS.

1.4.10 Vibration Limitation

The maximum engine-generator set vibration in the horizontal, vertical, and axial directions shall be limited to 6 mils (peak-peak RMS), with an overall velocity limit of 0.95 inches/second RMS, for all speeds through 110% of rated speed.

1.4.11 Vibration Isolation

The engine-generator set shall be provided with a vibration-isolation system in accordance with the manufacturer's standard recommendation. Vibration-isolation systems shall be designed and qualified as an integral part of the base and mounting system in accordance with the seismic parameters specified. Where the vibration-isolation system does not secure the base to the structure floor or unit foundation, seismic restraints shall be provided in accordance with the seismic parameters specified.

1.4.12 Seismic Requirements

Seismic requirements shall be in accordance with Sections 13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT, 15070 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT and 16070 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

1.4.13 Harmonic Requirements

Non-linear loads to be served by each engine-generator set are as indicated. The maximum linear load demand (kVA @ PF) when non-linear loads will also be in use is as indicated.

1.4.14 Starting Time Requirements

Upon receipt of a signal to start, each engine generator set will start, reach rated frequency and voltage and be ready to assume load within the time specified. For standby sets used in emergency power applications, each engine generator set will start, reach rated frequency and voltage, and power will be supplied to the load terminals of the Generator bus circuit breaker within the starting time specified.

1.4.15 Experience

Each component manufacturer shall have a minimum of 3 years experience in the manufacture, assembly and sale of components used with stationary diesel engine-generator sets for commercial and industrial use. The engine-generator set manufacturer/assembler shall have a minimum of 3 years experience in the manufacture, assembly and sale of stationary diesel engine-generator sets for commercial and industrial use.

1.4.16 Field Engineer

The engine-generator set manufacturer or assembler shall furnish a qualified field engineer to supervise the complete installation of the engine-generator set, assist in the performance of the onsite tests, and instruct personnel as to the operational and maintenance features of the equipment. The field engineer shall have attended the engine generator manufacturer's training courses on installation and operation and maintenance of engine generator sets.

1.4.17 Detailed Drawings

The Contractor shall submit detailed drawings showing the following:

a. Base-mounted equipment, complete with base and attachments, including anchor bolt template and recommended clearances for maintenance and operation.

b. Complete starting system.
c. Complete fuel system.
d. Complete cooling system.
e. Complete exhaust system.
f. Layout of relays, breakers, programmable controllers,switchgear, and switches including applicable single line and wiring diagrams with written description of sequence of operation and the instrumentation provided.

g. The complete lubrication system, including piping, pumps, strainers, filters, heat exchangers for lube oil and turbocharger cooling, controls and wiring.

h. Location, type, and description of vibration isolation devices for all applications.

i. The safety system, together with a detailed description of how it is to work. Wiring schematics, safety devices with a listing of their normal ranges, alarm and shutdown values (to include operation parameters such as pressures, temperatures voltages, currents, and speeds) shall be included.

j. One-line schematic and wiring diagrams of the generator, exciter, regulator, governor, and instrumentation.

k. Layout of each panel.

l. Mounting and support for each panel and major piece of electrical equipment.

m. Engine-generator set lifting points and rigging instructions.

1.4.18 Spare Parts

The Contractor shall submit a complete list of spare parts for each piece of equipment and a complete list of all material and supplies needed for continued operation. Lists shall include supply source and current prices. Each list shall be separated into two parts, those elements recommended by the manufacturer to be replaced after 3 years of service, and the remaining elements.

1.5 STORAGE AND INSTALLATION

The Contractor shall properly protect material and equipment, in accordance with the manufacturers recommended storage procedures,before, during, and after installation. Stored items shall be protected from the weather and contamination. During installation, piping and similar openings shall be capped to keep out dirt and other foreign matter.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

2.1.1 Filter Elements

Fuel-oil, lubricating-oil, and combustion-air filter elements shall be manufacturer's standard.

2.1.2 Instrument Transformers

ANSI C12.11.

2.1.3 Pipe (Sleeves, Fuel/Lube-Oil, Compressed Air, Coolant, and Exhaust)

ASTM A 53/A 53M, or ASTM A 106/A 106M steel pipe. Pipe smaller than 2 inches shall be Schedule 80. Pipe 2 inches and larger shall be Schedule 40.

a. Flanges and Flanged Fittings: ASTM A 181/A 181M, Class 60, or
ASME B16.5, Grade 1, Class 150.

b. Pipe Welding Fittings: ASTM A 234/A 234M, Grade WPB or WPC, Class
150 or ASME B16.11, 3000 lb.

c. Threaded Fittings: ASME B16.3, Class 150.

d. Valves: MSS SP-80, Class 150.

e. Gaskets: Manufacturer's standard.

2.1.4 Pipe Hangers

MSS SP-58 and MSS SP-69.

2.1.5 Electrical Enclosures

NEMA ICS 6.

2.1.5.1 Power Switchgear Assemblies

NEMA SG 6.

2.1.5.2 Panelboards

NEMA PB 1.

2.1.6 Electric Motors

Electric motors shall conform to the requirements of NEMA MG 1. Motors shall have sealed ball bearings and a maximum speed of 1800 rpm. Motors used indoors shall have drip-proof frames; those used outside shall be totally enclosed. Alternating current motors larger than 1/2 Hp shall be of the squirrel-cage induction type for operation on 208 volts 60 Hz, and three-phase power. Alternating current motors 1/2 Hp or smaller, shall be suitable for operation on 120 volts, 60 Hz, and single-phase power.

2.1.7 Motor Controllers

Motor controllers and starters shall conform to the requirements of NFPA 70 and NEMA ICS 2.

2.2 ENGINE

Each engine shall operate on No. 2-D diesel fuel conforming to ASTM D 975, shall be designed for stationary applications and shall be complete with ancillaries. The engine shall be a standard production model described in the manufacturer's catalog. The engine shall be naturally aspirated, supercharged, or turbocharged. The engine shall be 4-stroke-cycle and compression-ignition type. The engine shall be vertical in-line, V- or opposed-piston type, with a solid cast block or individually cast cylinders. Each block shall have a coolant drain port. Each engine shall be equipped with an overspeed sensor.

2.3 FUEL SYSTEM

The entire fuel system for each engine-generator set shall conform to the requirements of NFPA 30 and NFPA 37 and contain the following elements.

2.3.1 Pumps

2.3.1.1 Main Pump

Each engine shall be provided with an engine driven pump. The pump shall supply fuel at a minimum rate sufficient to provide the amount of fuel required to meet the performance indicated within the parameter schedule. The fuel flow rate shall be based on meeting the load requirements and all necessary recirculation.

2.3.2 Fuel Filter

A minimum of one full-flow fuel filter shall be provided for each engine. The filter shall be readily accessible and capable of being changed without

disconnecting the piping or disturbing other components. The filter shall have inlet and outlet connections plainly marked.

2.3.3 Relief/Bypass Valve

A relief/bypass valve shall be provided to regulate pressure in the fuel supply line, return excess fuel to a return line and prevent the build-up of excessive pressure in the fuel system.

2.3.4 Day Tank

Each engine shall be provided with integral day tank. Each day tank shall be provided with connections for fuel supply line, fuel return line, fuel overflow line, local fuel fill port, gauge, vent line, drain line, and float switch assembly for control. A fuel return line cooler shall be provided as recommended by the manufacturer and assembler. The temperature of the fuel returning to the day tank shall be below the flash point of the fuel. A temperature sensing device shall be installed in the fuel supply line, fuel overflow line, local fuel fill port, gauge, vent line, drain line, and float switch assembly for control. Each engine-generator set provided with weatherproof enclosures shall have its day tank mounted within the enclosure. The fuel fill line shall be accessible without opening the enclosure.

2.3.4.1 Capacity, Standby

Each day tank shall have capacity to supply fuel to the engine for an uninterrupted 4 hour period at 100% rated load without being refilled, plus any fuel which may be returned to the main fuel storage tank. The calculation of the capacity of each day tank shall incorporate the requirement to stop the supply of fuel into the day tank at 90% of the ultimate volume of the tank.

2.3.4.2 Drain Line

Each day tank drain line shall be accessible and equipped with a shutoff valve. Self-supporting day tanks shall be arranged to allow drainage into a 12 inch tall bucket.

2.3.4.3 Local Fuel Fill

Each local fuel fill port on the day tank shall be provided with a screw-on cap.

2.3.4.4 Fuel Level Controls

a. Each day tank shall have a float-switch assembly to perform the following functions:

(1) Start the supply of fuel into the day tank when the fuel level falls below the low level set point (75 percent) of the rated tank capacity.

(2) Stop the supply of fuel into the day tank when the level is above the 90% of the rated tank capacity.

(3) Activate the "Overfill Fuel Level" alarm at 95% of the rated tank capacity. A dry contact shall be available for interfacing with the control panel.

(4) Activate the "Low Fuel Level" alarm at 70% of the rated tank capacity. A dry contact shall be available for interfacing with the control panel.

(5) Activate the automatic fuel supply shut-off valve located on the fill line of the day tank and shut down the fuel pump which supplies fuel to the day tank at 95% of the rated tank capacity. The flow of fuel shall be stopped before any fuel can be forced into the fuel overflow line.

2.3.4.5 Arrangement

Integral day tanks may allow gravity flow into the engine. Gravity flow tanks shall be provided with an internal or external valve located as near as possible to the shell of the tank. The valve shall close when the engine is not operating. Integral day tanks shall be provided with any necessary pumps to supply fuel to the engine as recommended by the generator set manufacturer. The overflow connection and the fuel supply line for integral day tanks which do not rely upon gravity flow shall be arranged so that the highest possible fuel level is below the fuel injectors. When the main fuel storage tanks are located below the day tank, a check valve shall be provided in the fuel supply line entering the day tank. When the main fuel storage tanks are located above the day tank, a solenoid valve shall be installed in the fuel supply line entering the day tank. The solenoid valve shall be in addition to the automatic fuel shut off valve. The fuel supply line from the day tank to the manufacturer's standard engine connection shall be welded pipe.

2.3.5 Fuel Supply System

The fuel supply from the main storage of fuel to the day tank shall be as specified in Section 13202 FUEL STORAGE SYSTEMS with a total capacity of 168 hours of continuous operation without refueling..

2.4 LUBRICATION

Each engine shall have a separate lube-oil system conforming to NFPA 30 and NFPA 37. Each system shall be pressurized by engine-driven pumps. System pressure shall be regulated as recommended by the engine manufacturer. A pressure relief valve shall be provided on the crankcase for closed systems. The crankcase shall be vented in accordance with the manufacturer's recommendation except that it shall not be vented to the engine exhaust system. Crankcase breathers, if provided on engines installed in buildings or enclosures, shall be piped to vent to the outside. The system shall be readily accessible for service such as draining, refilling, etc. Each system shall permit addition of oil and have oil-level indication with the set operating. The system shall utilize an oil cooler as recommended by the engine manufacturer.

2.4.1 Lube-Oil Filter

One full-flow filter shall be provided for each pump. The filter shall be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. The filter shall have inlet and outlet connections plainly marked.

2.4.2 Lube-Oil Sensors

Each engine shall be equipped with lube-oil pressure sensors. Pressure sensors shall be located downstream of the filters and provide signals for required indication and alarms.

2.4.3 Precirculation Pump

A motor-driven precirculation pump powered by the station battery, complete with motor starter shall be provided if recommended by the engine manufacturer.

2.5 COOLING SYSTEM

Each engine shall have its own cooling system. Each system shall operate automatically while its engine is running. The cooling system coolant shall use a combination of water and ethylene-glycol sufficient for freeze protection at the minimum winter outdoor temperature specified. The maximum temperature rise of the coolant across each engine shall not exceed that recommended and submitted in paragraph SUBMITTALS.

2.5.1 Coolant Pumps

Coolant pumps shall be the centrifugal type. Each engine shall have an engine-driven primary pump. Secondary pumps shall be electric motor driven and have automatic controllers.

2.5.2 Heat Exchanger

Each heat exchanger shall be of a size and capacity to limit the maximum allowable temperature rise in the coolant across the engine to that recommended and submitted in paragraph SUBMITTALS for the maximum summer outdoor design temperature and site elevation. Each heat exchanger shall be corrosion resistant, suitable for service in ambient conditions of application.

2.5.2.1 Fin-Tube-Type Heat Exchanger (Radiator)

Heat exchanger may be factory coated with corrosive resistant film, provided that correction measures are taken to restore the heat rejection capability of the radiator to the initial design requirement via over sizing, or other compensating methods. Internal surfaces shall be compatible with liquid fluid coolant used. Materials and coolant are subject to approval by the Contracting Officer. Heat exchangers shall be pressure type incorporating a pressure valve, vacuum valve and a cap. Caps shall be designed for pressure relief prior to removal. Each heat exchanger and the entire cooling system shall be capable of withstanding a minimum pressure of 7 psi and shall be protected with a strong grille or screen guard. Each heat exchanger shall have at least two tapped holes; one tapped hole shall be equipped with a drain cock, the rest shall be plugged.

2.5.3 Expansion Tank

The cooling system shall include an air expansion tank which will accommodate the expanded water of the system generated within the normal operating temperature range, limiting the pressure increase at all components in the system to the maximum allowable pressure at those components. The tank shall be suitable for operating temperature of 250

degrees F and a working pressure of 125 psi. The tank shall be constructed of welded steel, tested and stamped in accordance with ASME BPVC SEC VIII D1 for the stated working pressure. A bladder type tank shall not used. The tank shall be supported by steel legs or bases for vertical or steel saddles for horizontal installation.

2.5.4 Thermostatic Control Valve

A modulating type, thermostatic control valve shall be provided in the coolant system to maintain the coolant temperature range submitted in paragraph SUBMITTALS.

2.5.5 Ductwork

Ductwork shall be as specified in Section 15895 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM except that a flexible connection shall be used to connect the duct to the diesel engine radiator. Material for the connection shall be wire-reinforced glass. The connection shall be rendered as airtight as possible.

2.5.6 Temperature Sensors

Each engine shall be equipped with coolant temperature sensors. Temperature sensors shall provide signals for pre-high and high indication and alarms.

2.6 SOUND LIMITATIONS

The noise generated by the diesel generator set operating at 100 percent load shall not exceed 62 db as measured 100 feet in any direction from the enclosure. Sound pressure measurments shall be taken in a free field at 45 degrees apart in all directions.

2.7 AIR INTAKE EQUIPMENT

Filters and silencers shall be provided in locations that are convenient for servicing. The silencer shall be of the high-frequency filter type, located in the air intake system as recommended by the engine manufacturer. Silencer shall be capable of reducing the noise level at the air intake so that the indicated pressure levels specified in paragraph SOUND LIMITATIONS will not be exceeded. A combined filter-silencer unit meeting requirements for the separate filter and silencer items may be provided. Expansion elements in air-intake lines shall be rubber.

2.8 EXHAUST SYSTEM

The system shall be separate and complete for each engine. Piping shall be supported to minimize vibration. Where a V-type engine is provided, a V-type connector, with necessary flexible sections and hardware, shall connect the engine exhaust outlets.

2.8.1 Flexible Sections and Expansion Joints

A flexible section shall be provided at each engine and an expansion joint at each muffler. Flexible sections and expansion joints shall have flanged connections. Flexible sections shall be made of convoluted seamless tube without joints or packing. Expansion joints shall be the bellows type. Expansion and flexible elements shall be stainless steel suitable for diesel-engine exhaust gas at the maximum exhaust temperature that is

specified by the engine manufacturer. Expansion and flexible elements shall be capable of absorbing vibration from the engine and compensation for thermal expansion and contraction.

2.8.2 Exhaust Muffler

A chamber type exhaust muffler shall be provided. The muffler shall be constructed of welded steel and designed for outsidehorizontal mounting. Eyebolts, lugs, flanges, or other items shall be provided as necessary for support in the location and position indicated. Pressure drop through the muffler shall not exceed the recommendations of the engine manufacturer. Outside mufflers shall be zinc coated or painted with high temperature 900 degrees resisting paint. The muffler and exhaust piping together shall reduce the noise level to less than the maximum acceptable level listed for sound limitations in paragraph SOUND LIMITATIONS. The muffler shall have a drain valve, nipple, and cap at the low-point of the muffler.

2.8.3 Exhaust Piping

Horizontal sections of exhaust piping shall be sloped downward away from the engine to a drip leg for collection of condensate with drain valve and cap. Changes in direction shall be long radius. Vertical exhaust piping shall be provided with a hinged, gravity-operated, self-closing, rain cover.

2.9 PYROMETER

A pyrometer, multi-point selector switch, and individual thermocouples with calibrated leads shall be provided to show the temperature in each engine cylinder and the combined exhaust. For a supercharged engine, additional points, thermocouples and leads shall be provided to show the temperature in the turbocharger exhaust gas outlet and combustion air discharge passages. Graduated scale length shall be not less than 6 inches. The selector switch shall be double pole, with an "off" position, one set of points for each thermocouple, and suitable indicating dial. The pyrometer, thermocouples, leads and compensating devices shall be calibrated to show true exhaust temperature within plus or minus 1% above the highest temperature encountered at 110% load conditions. Provide RS485 BacNet for transfer of the above mentioned information to the Dedicated Electrical Monitoring and Control System.

2.10 EMISSIONS

The finished installation shall comply with Federal, state, and local regulations and restrictions regarding the limits of emissions.

2.11 STARTING SYSTEM

Each engine generator set shall be capable of a "black start"; independent of other generators and without shored starting systems components such as batteries or chargers. The starting system for standby engine generator sets used in emergency applications shall be in accordance with NFPA 99 and NFPA 110and as follows.

2.11.1 Controls

An engine control switch shall be provided with functions including: run/start(manual), off/reset, and, automatic mode. Start-stop logic shall be provided for adjustable cycle cranking and cooldown operation. The logic shall be arranged for manual starting and fully automatic starting in accordance with paragraph AUTOMATIC ENGINE-GENERATOR-SET SYSTEM OPERATION.

Electrical starting systems shall be provided with an adjustable cranking limit device to limit cranking periods from 1 second up to the maximum duration.

2.11.2 Capacity

The starting system shall be of sufficient capacity, at the maximum outdoor summer temperature specified to crank the engine without damage or overheating. The system shall be capable of providing a minimum of three cranking periods with 15 second intervals between cranks. Each cranking period shall have a maximum duration of 15 seconds.

2.11.3 Electrical Starting

Manufacturers recommended dc system, utilizing a negative circuit ground.

2.11.3.1 Battery

A starting battery system shall be provided and shall include the battery, battery rack, intercell connectors, spacers, automatic battery charger with overcurrent protection. The battery shall be in accordance with SAE J537. Critical system components (rack, protection, etc.) shall be sized to withstand the seismic acceleration forces specified. The battery shall be lead-acid, with sufficient capacity, at the minimum outdoor and maximum outdoor temperature specified, to provide the specified cranking periods. Valve-regulated lead-acid batteries are not acceptable.

2.11.3.2 Battery Charger

A current-limiting battery charger, conforming to UL 1236, shall be provided and shall automatically recharge the batteries. The charger shall be capable of an equalize-charging rate for recharging fully depleted batteries within 24 hours which is manually adjustable in a continuous range and a floating charge rate for maintaining the batteries at fully charged condition. An ammeter shall be provided to indicate charging rate. A voltmeter shall be provided to indicate charging voltage. A timer shall be provided for the equalize-charging-rate setting. A battery is considered to be fully depleted when the output voltage falls to a value which will not operate the engine generator set and its components.

2.11.4 Starting Aids

The manufacturer shall provide one or more of other following methods to assist engine starting.

2.11.4.1 Jacket-Coolant Heaters

A thermostatically controlled electric heater shall be mounted in the engine coolant jacketing to automatically maintain the coolant within plus or minus 3 degrees F of the control temperature. The heater shall operate independently of engine operation so that starting times are minimized. Power for the heaters shall be 208 volts ac.

a. Standby Rated Sets
The control temperature shall be the temperature recommended by the engine manufacturer to meet the starting time specified at the minimum winter outdoor temperature.

2.11.4.2 Lubricating-Oil Heaters

A thermostatically controlled electric heater shall be mounted in the engine lubricating-oil system to automatically maintain the oil temperature within plus or minus 3 degrees F of the control temperature. The heater shall operate independently of engine operation so that starting times are minimized. Power for the heaters shall be 208 volts ac.

2.12 GOVERNOR

Each engine shall be provided with a governor which maintains the frequency within a bandwidth of the rated frequency, over a steady-state load range of zero to 100% of rated output capacity. The governor shall be configured for safe manual adjustment of the speed/frequency during operation of the engine-generator set, without special tools, from 90 to 110% of the rated speed/frequency, over a steady state load range of 0 to 100% or rated capacity. Droop governors shall maintain the midpoint of the frequency bandwidths linearly of steady state loads over the range of zero to 100 percent of rated output capacity, with 3 percent droop.

2.13 GENERATOR

Each generator shall be of the synchronous type, single bearing, conforming to the performance criteria in NEMA MG 1, equipped with winding terminal housings in accordance with NEMA MG 1, equipped with an amortisseur winding, and directly connected to the engine. Insulation shall be Class F. Generator design shall protect against mechanical, electrical and thermal damage due to vibration, 25% overspeeds, or voltages and temperatures at a rated output capacity of 110%. Generator ancillary equipment shall meet the short circuit requirements of NEMA MG 1. Frames shall be the drip-proof type.

2.13.1 Current Balance

At 100% rated output capacity, and load impedance equal for each of the 3 phases, the permissible current difference between any 2 phases shall not exceed 2% of the largest current on either of the 2 phases.

2.13.2 Voltage Balance

At any balanced load between 75 and 100% of rated output capacity, the difference in line-to-neutral voltage among the 3 phases shall not exceed 1% of the average line-to-neutral voltage. For a single-phase load condition, consisting of 25% load at unity power factor placed between any phase and neutral with no load on the other 2 phases, the maximum simultaneous difference in line-to-neutral voltage between the phases shall not exceed 3% of rated line to neutral voltage. The single-phase load requirement shall be valid utilizing normal exciter and regulator control. The interpretation of the 25% load for single phase load conditions means 25% of rated current at rated phase voltage and unity power factor.

2.13.3 Waveform

The deviation factor of the line-to-line voltage at zero load and at balanced rated output capacity shall not exceed 10%. The RMS of all harmonics shall be less than 5.0% and that of any one harmonic less than 3.0% of the fundamental at rated output capacity. Each engine-generator shall be designed and configured to meet the total harmonic distortion

limits of IEEE Std 519.

2.14 EXCITER

The generator exciter shall be of the brushless type. Semiconductor rectifiers shall have a minimum safety factor of 300% for peak inverse voltage and forward current ratings for all operating conditions, including 110% generator output at 104 degrees F ambient. The exciter and regulator in combination shall maintain generator-output voltage within the limits specified.

2.15 VOLTAGE REGULATOR

Each generator shall be provided with a solid-state voltage regulator, separate from the exciter. The regulator shall maintain the voltage within a bandwidth of the rated voltage, over a steady-state load range of zero to 100% of rated output capacity. Regulator shall be configured for safe manual adjustment of the engine-generator voltage output without special tools, during operation, from 90 to 110% of the rated voltage over the steady state load range of 0 to 100% of rated output capacity. Regulation drift shall not exceed plus or minus 0.5% for an ambient temperature change of 68 degrees F. Reactive droop compensation or reactive differential compensation shall load share the reactive load proportionally between sets during parallel operation. The voltage regulator shall have a maximum droop of 2% of rated voltage over a load range from 0 to 100% of rated output capacity and automatically maintain the generator output voltage within the specified operational bandwidth.

2.16 GENERATOR ISOLATION AND PROTECTION

Devices necessary for electrical protection and isolation of each engine-generator set and its ancillary equipment shall be provided. The generator circuit breaker (IEEE Device 52) ratings shall be consistent with the generator rated voltage and frequency, with continuous, short circuit withstand, and interrupting current ratings to match the generator capacity. The generator circuit breaker shall be electrically operated. A set of surge capacitors, to be mounted at the generator terminals shall be provided. Monitoring and control devices shall be as specified in paragraph GENERATOR PANEL.

2.16.1 Stator Temperature Detectors

Provide platinum wire type resistance temperature detectors (RTD), rated 100 ohms at 0 degrees C, in generator stator windings. Provide two RTDs per phase. Provide RTDs prewired to labeled terminal blocks in connection box described below. Provide a temperature display, alarm, and trip contacts with adjustable set points. Trip contacts shall trip generator circuit breaker and put engine in cool down mode.

2.16.2 Bearing Temperature Detectors

Provide platinum wire type RTD, rated 100 ohms at 0 degrees C, at each generator bearing. Provide RTDs prewired to labeled terminal blocks in the connection box described below. Provide a temperature display, alarm, and trip contacts with adjustable set points. Trip contacts shall immediately trip the generator circuit breaker and immediately stop the engine.

2.16.3 Connection Box

Provide a suitable connection box, separate from the main terminal box for all RTD and stator space heater leads.

2.16.4 Sustained Short-Circuit Current

For a 3-phase bolted short circuit at the system output terminals, the system shall supply a minimum of 250 percent of rated full load current for 10 seconds.

2.16.5 Switchgear

Switchgear shall be free-standing, metal-clad, 3-phase, 4-wire, 12.47 kV rated, with neutral bus and continuous ground bus, conforming to IEEE C27.20.1. Neutral bus and ground bus capacity shall be as shown full capacity. Enclosure designs, construction, materials, and coatings shall be suitable for the application and environment. Bus continuous current rating shall be as indicated. Switchgear shall be complete with control for starting and controlling engine-generators, paralleling of engine-generators, paralleling with utility, import-export control, and automatic adding and shedding of engine-generators based on real-time loads. Provide air-conditioned switchgear enclosure for MVSG-GA and MVSG-GB,, complete with station power, ground bus, smoke detectors, rough-ins for motion detectors, control power batteries, dc panelboard and chargers, lighting, convenience receptacles, personnel, and equipment doors, rear doors and feeder access, and ac panelboards. The switchgear enclosure shall be suitable for mounting on a concrete pad. Certified drawings shall be provided indicating the concrete slab dimension and mounting details.

2.16.6 Devices

Switches, circuit breakers, switchgear, fuses, relays, and other protective devices shall be as specified in Section 16475 COORDINATED POWER SYSTEM PROTECTION.

2.17 SAFETY SYSTEM

Devices, wiring, remote panels, local panels, etc. shall be provided and installed as a complete system to automatically activate the appropriate signals and initiate the appropriate actions. The safety system shall be provided with a self-test method to verify its operability. Alarm signals shall have manual acknowledgment and reset devices. The alarm signal systems shall reactivate for new signals after acknowledgment is given to any signal. The systems shall be configured so that loss of any monitoring device shall be dealt with as an alarm on that system element.

shutdown.

2.17.2 Alarms and Action Logic

2.17.2.1 Shutdown

Simultaneous activation of the audible signal, activation of the visual signal, activation of the strobe signal, stopping the engine, and opening the generator main circuit breakers shall be accomplished.

2.17.2.2 Problem

Activation of the visual signal shall be accomplished.

2.17.3 Local Alarm Panel

A local alarm panel shall be provided with the following shutdown and alarm functions as indicated in accordance with NFPA 110 level 1 Corps of Engineer requirements mounted either on or adjacent to the engine generator set.

Device/Condition /Function	What/Where/Size	NFPA 110 Level 1	Corps of Engrs Required
Shutdowns w/Alarms			
High engine temperature	Automatic/jacket/ water/cylinder	SD/CP VA	SD VA
Low lube-oil pressure	Automatic/pressure/ level	SD/CP VA	SD VA
Overspeed Shutdown& Alarm	(110 percent (+ 2 % of rated speed)	SD/CP VA	SD VA
Overcrank, Failure to start	Automatic/Failure to start	SD/CP	VA
Day tank overfill limit indication & transfer pump shutdown (95 % volume)	Automatic/Day Tank/Level CP VA	SD/CP	VA SD(Pump)
Red emergency stop switch	Manual Switch	SD/CP VA	SD VA
Alarms			
Day Tank	Automatic/Day		CP VA
Low fuel level	Main tank, 24 hrs remaining	CP VA	CP VA

Device/Condition /Function	What/Where/Size	NFPA 110 Level 1	Corps of Engrs

Integral Main Fuel Storage Tank High Fuel Level	95% volume		Required CP VA
Low Coolant Temperature	jacket water	CP VA	
Pre-High Temperature	jacket water/ Cylinder	CP VA	CP VA
Pre-Low Lube-oil Pressure			CP VA
High battery Voltage		CP VA	
Low battery Voltage		CP VA	
Battery charger Failure	AC supply not AC available	CP VA	
Control switch not in AUTO		CP VA	
Low starting Air pressure		CP VA	
Low starting hydraulic pressure		CP VA	

SD - Shut Down
CP - On Control Panel
VA - Visual Alarm
AA - Audible Alarm

2.17.4 Time-Delay on Alarms

For startup of the engine-generator set, time-delay devices shall be installed bypassing the low lubricating oil pressure alarm during cranking, and the coolant-fluid outlet temperature alarm. The lube-oil time-delay device shall return its alarm to normal status 30 seconds (adjustable between 15 and 90 seconds) after the engine starts. The coolant time-delay device shall return its alarm to normal status 5 minutes after the engine starts.

2.17.5 Remote Alarm Panel

A remote alarm panel shall be provided in accordance with NFPA 110 and as follows.

Device/Condition/Function	What/Where/Size	NFPA 110 Level 1
Remote annunciator panel	Battery Powered	Alarms

Loads on genset		
Battery charger malfunction		
Low lube-oil	Pressure/level	VA/AA
Low temperature	Jacket water	VA/AA
High temperature	Jacket water/ cylinder	VA/AA
Low fuel level remaining	Main tank, 3 hrs	VA/AA
Overcrank	Failure to start	VA/AA
Overspeed VA/AA		
Pre-high temperature	Jacket water/ cylinder	VA/AA
Control switch not in AUTO VA/AA		
Common alarm contacts for X local & remote common alarm		
Audible alarm silencing X switch		
Air shutdown damper	When used	VA/AA
Common fault alarm		VA/AA

X - Required
SD - Shutdown
CP - On Control Panel
VA - Visual Alarm
AA - Audible Alarm
O – Optional

2.18 ENGINE GENERATOR SET CONTROLS AND INSTRUMENTATION

Devices, wiring, remote panels, local panels, etc. shall be provided and installed as a complete system to automatically activate the appropriate signals and initiate the appropriate actions.

2.18.1 Controls

A local control panel shall be provided with controls in accordance with NFPA 110 level 1 and as follows mounted either adjacent to the engine generator set. A remote control panel shall be provided fully redundant to the local control panel.

Device/Condition/ Function	Corps Requirement	NFPA 110 Level 1
Controls		
Switch: run/start - off/reset - auto	CP	
Emergency stop switch & alarm	CP	
Lamp test/indicator test	CP	CP VA
Common alarm contacts/ fault relay		X
Panel lighting	CP	

Device/Condition/ Function	Corps Requirement	NFPA 110 Level 1
Audible alarm & silencing/reset switch	CP	

Voltage adjust for voltage regulator	CP	
Pyrometer display w/selector switch	CP	
Remote emergency stop switch		CP VA
Remote fuel shutoff switch		
Remote lube-oil shutoff switch		

2.18.2 Engine Generator Set Metering and Status Indication

A local panel shall be provided with devices in accordance with NFPA 110 level 1 adjacent to the engine generator set. A remote control panel shall be provided fully redundant to the local control panel.

Device/Condition/ Function	Corps Requirement	NFPA 110 Level 1
Genset Status & Metering		
Genset supplying load		CP VA
System ready		
Engine oil pressure	CP	
Engine coolant temperature	CP	
Engine RPM (tachometer)	CP	
Engine run hours	CP	
Pyrometer display w/selector switch	CP	
AC volts (generator), 3-phase	CP	
AC amps (generator), 3 - phase	CP	
Generator Frequency	CP	
Phase selector switches (amps & volts)	CP	
Watts/kW		
Voltage Regulator Adjustment	CP	

X – Required

CP - On Control Panel
VA - Visual Alarm
AA - Audible Alarm
STD- Manufacturers Standard Offering

2.18.3 Dedicated Electrical Monitoring and Control System

a. The generator, fuel system, power meters, protection relays, circuit breakers, plant PLC, and associated switchgear shall be connected to the Dedicated Electrical Monitoring and Control System.

b. Testing/exercising shall be capable of being performed through the Dedicated Electrical Monitoring and Control System.

c.Monitored points (each generator shall be monitored independently):

1. kW
2. Power factors
3. Frequency
4. Current
5. Voltage
6. Day tank fuel level
7. Main tank fuel level

2.19 SYNCHRONIZING PANEL

The panel shall be as specified in paragraph PANELS and shall provide controls, gauges, meters, and displays to include:

a. Frequency meters, dial type, with a range of 90 to 110% of rated frequency. Vibrating-reed type meters shall not be used. One shall monitor generator output frequency ("Generator Frequency Meter") and the other shall monitor the frequency of the parallel source ("Bus Frequency Meter").

b. Voltmeters, ac, dial type, 3-phase, with 4-position selector switch for the generator output ("Generator Volt Meter") and for the parallel power source ("Bus volt meter").

b. Automatic synchronizer.

c. Manual synchronizing controls.

d. Indicating lights for supplementary indication of synchronization.

e. Synchroscope.

f. Wattmeter, indicating.

2.20 PANELS

Each panel shall be of the type and kind necessary to provide specified functions. Panels shall be mounted on the engine-generator set base by vibration/shock absorbing type mountings as shown. Instruments shall be mounted flush or semiflush. Convenient access to the back of panels shall be provided to facilitate maintenance. Instruments shall be calibrated using recognized industry calibration standards. Each panel shall be provided with a panel identification plate which clearly identifies the panel function. Each instrument and device on the panel shall be provided with a plate which clearly identifies the device and its function as indicated. Switch plates shall clearly identify the switch-position function.

2.20.1 Enclosures

Enclosures shall be designed for the application and environment,

conforming to NEMA ICS 6. Locking mechanisms shall be keyed alike.

2.20.2 Electronic

Electronic indicating instruments shall be true RMS indicating instruments, 100% solid state, state-of-the-art, microprocessor controlled to provide specified functions. Control, logic, and function devices shall be compatible as a system, sealed, dust and water tight, and shall utilize modular components with metal housings and digital instrumentation. An interface module shall be provided to decode serial link data from the electronic panel and translate alarm, fault and status conditions to set of relay contacts. Instrument accuracy shall be not less than 98% for unit mounted devices and 99% for control room, panel mounted devices, throughout a temperature range of minus 4 to 158 degrees F. Data display shall utilize LED or back lit LCD. Additionally, the display shall provide indication of cycle programming and diagnostic codes for troubleshooting. Numeral height shall be 0.5 inch.

2.20.3 Parameter Display

Indication or readouts of the tachometer, lubricating-oil pressure, ac voltmeter, ac ammeter, frequency meter, and safety system parameters shall be provided. A momentary switch shall be specified for other panels.

2.21 AUTOMATIC ENGINE-GENERATOR-SET SYSTEM OPERATION

Fully automatic operation shall be provided for the following operations: engine-generator set starting and load transfer upon loss of normal source; retransfer upon restoration of the normal source; sequential starting; paralleling, and load-sharing for multiple engine-generator sets; and stopping of each engine-generator set after cool-down. Devices shall automatically reset after termination of their function.

2.21.1 Automatic Transfer Switch

Automatic transfer switches shall be in accordance with Section 16410 AUTOMATIC TRANSFER SWITCH AND BY-PASS/INSOLATION SWITCH.

2.21.2 Monitoring and Transfer

Devices shall be provided to monitor voltage and frequency for the normal power source and each engine-generator set, and control transfer from the normal source and retransfer upon restoration of the normal source. Functions, actuation, and time delays shall be as described in Section 16410 AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH.

2.21.3 Automatic Paralleling and Loading of Engine-Generator Sets

An automatic loading system shall be provided to load and unload engine-generator sets in the sequence indicated. The loading system shall monitor the system load and cause additional engine-generator sets to start, synchronize, and be connected in parallel with the system bus with increasing load. Actuation of the additional engine-generator set start logic shall occur when the load exceeds a percentage setpoint of the operating set's rating for a period of approximately 10 seconds. The device shall provide an adjustable setpoint range from 50 to 100%. When the system load falls below the percentage setpoint of the operating set's rating for a period of approximately 2 minutes, the controller shall unload and disconnect engine-generator sets from the system, stopping each

engine-generator set after cool-down.

2.22 MANUAL ENGINE-GENERATOR-SET SYSTEM OPERATION

Complete facilities shall be provided for manual starting and testing of each set without load, loading and unloading of each set, and synchronization of each set with an energized bus.

2.23 STATION BATTERY SYSTEM

A station battery system shall be provided to include the battery, battery rack, spacers, automatic battery charger and distribution panelboard with overcurrent protection, metering and relaying. Components shall be sized to withstand the seismic acceleration forces specified. The batteries shall have a rated life of 20 years and a manufacturer's 5-year, no cost replacement guarantee.

2.23.1 Battery

The battery shall be lead-acid, sized in accordance with IEEE Std 485 and conform to the requirements of IEEE Std 484. Valve-regulated lead-acid batteries are not acceptable.The battery environment temperature shall range between 0 and 110 degrees F.

2.23.2 Battery Capacity

The batteries shall be rated for at least six 30 second cranks, and operate diesel generator safety circuits and voltage regulator (dc power supplies). Final cell voltages at end of discharge shall be at least 1.75 volts per cell. At the end of the discharge period, the battery shall have the capacity to sequential close and trip all the circuit breakers provided, based on a 1 minute load to a final voltage of 1.75 volts per cell.

2.23.3 Battery Charger

A current-limiting, 120-volt battery charger shall be furnished to automatically recharge the batteries. The charger shall be capable of an equalize charging rate for recharging fully depleted batteries within 8 hours which is continuously adjustable and a floating-charge rate for maintaining the batteries in a fully charged condition. The charger shall be equipped with a low-voltage alarm relay, 0- to 24-hour equalizing timer, an ammeter to indicate charging rate, and necessary circuit breakers. The charger shall conform to the requirements of UL 1236. A battery is considered to be fully depleted when the voltage falls to a level incapable of operating the equipment loads served by the battery.

2.24 BASE

The base shall be constructed of steel. The base shall be designed to rigidly support the engine-generator set, ensure permanent alignment of rotating parts, be arranged to provide easy access to allow changing of lube-oil, and ensure that alignment is maintained during shipping and normal operation. The base shall permit skidding in any direction during installation and shall withstand and mitigate the affects of synchronous vibration of the engine and generator. The base shall be provided with suitable holes for anchor bolts and jacking screws for leveling.

2.25 THERMAL INSULATION

Thermal insulation shall be as specified in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.26 PAINTING AND FINISHING

The engine-generator set shall be cleaned, primed and painted in accordance with the manufacturer's standard color and practice.

2.27 FACTORY INSPECTION AND TESTS

The factory tests shall be performed on each engine-generator set. The component manufacturer's production line test is acceptable as noted. Each engine-generator set shall be run not less than 1 hour at rated output capacity prior to inspections. Inspections shall be completed and all necessary repairs made, prior to testing. Engine generator controls and protective devices that are provided by the generator set manufacturer as part of the standard package shall be used for factory tests. When controls and switchgear are not provided as part of the generator set manufacturer's standard package, the actual controls and protective devices provided for the project are not required to be used during the factory test. The Contracting Officer may provide one or more representatives to witness inspections and tests.

2.27.1 Factory Inspection

Inspections shall be performed prior to beginning and after completion of testing of the assembled engine-generator set. Inspectors shall look for leaks, looseness, defects in components, proper assembly, etc. and any item found to be in need of correction shall be noted as a necessary repair. The following checklist shall be used for the inspection:

INSPECTION ITEM

1. Drive belts
2. Governor and adjustments
3. Engine timing mark
4. Starting motor
5. Starting aids
6. Coolant type and concentration
7. Radiator drains
8. Block coolant drains
9. Coolant fill level
10. All coolant line connections
11. All coolant hoses
12. Combustion air filter
13. Combustion air silencer
14. Lube oil type
15. Lube oil sump drain
16. Lube-oil filter
17. Lube-oil-level indicator
18. Lube-oil-fill level
19. All lube-oil line connections
20. All lube-oil lines
21. Fuel type and amount
22. All fuel-line connections
23. All fuel lines
24. Fuel filter
25. Coupling and shaft alignment
26. Voltage regulators
27. Battery-charger connections
28. All wiring connections
29. Instrumentation
30. Hazards to personnel
31. Base
32. Nameplates
33. Paint
34. Exhaust-heat recovery unit
35. Switchboard
36. Switchgear

2.27.2 Factory Tests

Engine and generator are required to be connected and operated together, the load power factor shall be the power factor specified in the engine generator set parameter schedule .. Electrical measurements shall be performed in accordance with IEEE Std 120. Definitions of terms are in accordance with IEEE Std 100. Temperature limits in the rating of electrical equipment and for the evaluation of electrical insulation shall be in accordance with IEEE Std 1. In the following tests where measurements are to be recorded after stabilization of an engine-generator set parameter (voltage, frequency, current, temperature, etc.), stabilization is considered to have occurred when measurements are maintained within the specified bandwidths or tolerances, for a minimum of four consecutive readings. Tests specifically for the generator may be performed utilizing any prime mover.

a. Insulation Resistance for Stator and Exciter Test, IEEE Std 115 and IEEE Std 43, to the performance criteria in NEMA MG 1, Part 22. Generator manufacturer's production line test is acceptable.

b. High Potential Test, per IEEE Std 115 and NEMA MG 1, test voltage in accordance with NEMA MG 1. Generator manufacturer's production line test is acceptable.

c. Winding Resistance Test, Stator and Exciter, per IEEE Std 115. Generator manufacturer's production line test is acceptable.

d. Overspeed Vibration Test, per IEEE Std 115 to the performance criteria in NEMA MG 1. The test shall be performed at 110% of rated speed for 5 minutes. The vibration shall be measured at the end bearings (front and back of engine, outboard end of generator) in the horizontal, vertical, and axial directions. Vibration amplitude and speed shall be recorded at one minute intervals.

e. Phase Balance Voltage Test, to the performance criteria specified in paragraph GENERATOR. This test can be performed with any prime mover. Generator manufacturer's production line test results are acceptable.

(1) Start and operate the generator at no load.

(2) Adjust a regulated phase voltage (line-to-neutral) to rated voltage.

(3) Read and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

(4) Apply 75% rated load and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

(5) Apply rated load and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

(6) Calculate average line-neutral voltage and percent deviation of individual line-neutral voltages from average for each load condition.

f. Current Balance on Stator Winding Test, by measuring the current on each phase of the winding with the generator operating at 100 % of Rated Output Capacity, with the load impedance equal for each of the three phases: to the performance criteria specified in paragraph GENERATOR.

g. Voltage Waveform Deviation and Distortion Test per IEEE Std 115 to the performance criteria specified in paragraph GENERATOR.

High-speed recording instruments capable of recording voltage waveform deviation and all distortion, including harmonic distortion shall be used. Representation of results shall include appropriate scales to provide a means to measure and interpret results.

h. Voltage and Frequency Droop Test. Verify that the output voltage and frequency are within the specified parameters as follows:

(1) With the generator operating at no load, adjust voltage and frequency to rated voltage and frequency. Record the generator output frequency and line-line and line-neutral voltages.

(2) Increase load to Rated Output Capacity. Record the generator output frequency and line-line and line-neutral voltages.

(3) Calculate the percent droop for voltage and frequency with the following equations:

$$\text{Voltage droop \%} = \frac{\text{(No-Load Volts) - (Rated Capacity volts)}}{\text{(Service-Load Volts)}} \times 100$$

$$\text{Frequency droop \%} = \frac{\text{(No-Load Hertz) - (Rated Capacity hertz)}}{\text{(Service-Load hertz)}} \times 100$$

(4) Repeat steps 1 through 3 two additional times without making any adjustments.

i. Frequency and Voltage Stability and Transient Response. Verify that the engine-generator set responds to addition and dropping of blocks of load in accordance with the transient response requirements. Document maximum voltage and frequency variation from bandwidth and verify that voltage and frequency return to and stabilize within the specified bandwidth, within the specified response time period. Document results in tabular form and with high resolution, high speed strip chart recorders or comparable digital recorders, as approved by the Contracting Officer.

Tabular data shall include the following:

(1) Ambient temperature (at 15 minute intervals).

(2) Generator output current (before and after load changes).

(3) Generator output voltage (before and after load changes).

(4) Frequency (before and after load changes).

(5) Generator output power (before and after load changes).

(6) Graphic representations shall include the actual instrument trace of voltage and frequency showing: charts marked at start of test; observed steady-state band; mean of observed band; momentary overshoot and undershoot (generator terminal voltage and frequency) and recovery time for each load change together with the voltage and frequency maximum and minimum trace excursions for each steady state load condition prior to and immediately following each load change. Generator terminal voltage and frequency transient recovery time for each step load increase and decrease.

(a) Perform and record engine manufacturer's recommended prestarting checks and inspections.

(b) Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period and no load. Verify stabilization of voltage and frequency within specified bandwidths.

(c) With the unit at no load, apply the Maximum Step Load Increase.

(d) Apply load in steps equal to the Maximum Step Load Increase until the addition of one more step increase will exceed the Service Load.

(e) Decrease load to the unit such that addition of the Maximum Step Load Increase will load the unit to 100% of Service Load.

(f) Apply the Maximum Step Load Increase.

(g) Decrease load to zero percent in steps equal to the Maximum Step Load Decrease.

(h) Repeat steps 3. through 7.

j. Test Voltage Unbalance with Unbalanced Load (Line-to-Neutral) to the performance criteria specified in paragraph GENERATOR. Prototype test data is acceptable in lieu of the actual test. This test may be performed using any prime mover.

(1) Start and operate the generator set at rate voltage, no load, rated frequency, and under control of the voltage regulator. Read and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

(2)Apply the specified load between terminals L_1-L_2, L_2-L_0, and L_3-L_0 in turn. Record all instrument readings at each line-neutral

condition.

(3) Express the greatest difference between any two of the line-to-line voltages and any two of the line-to-neutral voltages as a percent of rated voltage.

(4) Compare the largest differences expressed in percent with the maximum allowable difference specified.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION

Installation shall provide clear space for operation and maintenance in accordance with NFPA 70 and IEEE C2. Installation of pipe, duct, conduit, and ancillary equipment shall be configured to facilitate easy removal and replacement of major components and parts of the engine-generator set.

3.2 PIPING INSTALLATION

Piping shall be welded. Connections at valves shall be flanged. Connections at equipment shall be flanged except that connections to the diesel engine may be threaded if the diesel-engine manufacturers standard connection is threaded. Except where otherwise specified, welded flanged fittings shall be utilized to allow for complete dismantling and removal of each piping system from the facility without disconnecting or removing any portion of any other system's equipment or piping. Connections to equipment shall be made with vibration-isolation-type flexible connectors. Piping and tubing shall be supported and aligned to prevent stressing of flexible hoses and connectors. Pipes extending through the roof shall be properly flashed. Piping shall be installed clear of windows, doors and openings, to permit thermal expansion and contraction without damage to joints or hangers, and shall be installed with a 1/2 inch drain valve with cap at each low point and a 1/2 inch vent valve at each high point.

3.2.1 Support

Hangers, inserts, and supports shall be of sufficient size to accommodate any insulation and shall conform to MSS SP-58 and MSS SP-69. Supports shall be spaced not more than 7 feet on center for pipes 2 inches in diameter or less, not more than 12 feet on center for pipes larger than 2 inches but smaller than 4 inches in diameter, and not more than 17 feet on center for pipes larger than 4 inches in diameter. Supports shall be provided at pipe bends or change of direction.

3.2.1.1 Ceiling and Roof

Exhaust piping shall be supported with appropriately sized Type 41 single pipe roll and threaded rods; all other piping shall be supported with appropriately sized Type 1 clevis and threaded rods.

3.2.1.2 Wall

Wall supports for pipe shall be made by suspending the pipe from appropriately sized Type 33 brackets with the appropriate ceiling and roof pipe supports.

3.2.2 Flanged Joints

Flanges shall be Class 125 type, drilled, and of the proper size and configuration to match the equipment and diesel engine connections. Flanged joints shall be gasketed and made up square and tight.

3.2.3 Cleaning

After fabrication and before assembly, piping interiors shall be manually wiped clean of debris.

3.2.4 Pipe Sleeves

Pipes passing through construction such as ceilings, floors, or walls shall be fitted with sleeves. Each sleeve shall extend through and be securely fastened in its respective structure and shall be cut flush with each surface. The structure shall be built tightly to the sleeve. The inside diameter of each sleeve shall be minimum 1/2 inch, and where pipes pass through combustible materials 1 inch larger than the outside diameter of the passing pipe or pipe insulation/covering.

3.3 ELECTRICAL INSTALLATION

Electrical installation shall comply with NFPA 70, IEEE C2, and Section

16402 INTERIOR DISTRIBUTION SYSTEM. For vibration isolation, flexible fittings shall be provided for conduit, cable trays, and raceways attached to engine-generator sets; metallic conductor cables installed on the engine generator set and from the engine generator set to equipment not mounted on the engine generator set shall be flexible stranded conductor; and terminations of conductors on the engine generator set shall be crimp-type terminals or lugs.

3.4 FIELD PAINTING

Field painting shall be as specified in Section 09900 PAINTS AND COATINGS.

3.5 ONSITE INSPECTION AND TESTS

3.5.1 Test Conditions

3.5.1.1 Data

Measurements shall be made and recorded of all parameters necessary to verify that each set meets specified parameters. If the results of any test step are not satisfactory, adjustments, replacements, or repairs shall be made and the step repeated until satisfactory results are obtained. Unless otherwise indicated, data shall be recorded in 15 minute intervals during engine-generator set operation and shall include: readings of all engine-generator set meters and gauges for electrical and power parameters; oil pressure; ambient temperature; and engine temperatures available from meters and gauges supplied as permanent equipment on the engine-generator set. Electrical measurements shall be performed in accordance with IEEE Std 120. Definitions of terms are in accordance with IEEE Std 100. Temperature limits in the rating of electrical equipment and for the evaluation of electrical insulations shall be in accordance with IEEE Std 1.

3.5.1.2 Power Factor

For all engine-generator set operating tests the load power factor shall be

the power factor specified in the engine-generator set parameter schedule.

3.5.1.3 Contractor Supplied Items

The Contractor shall provide equipment and supplies required for inspections and tests including fuel, test instruments, and loadbanks at the specified power factors.

3.5.1.4 Instruments

Readings of panel gauges, meters, displays, and instruments provided as permanent equipment shall be verified during test runs, using test instruments of greater precision and accuracy. Test instrument accuracy shall be within the following: current plus or minus 1.5%, voltage plus or minus 1.5%, real power plus or minus 1.5%, reactive power plus or minus 1.5%, power factor plus or minus 3%, frequency plus or minus 0.5%. Test instruments shall be calibrated by a recognized standards laboratory within 30 days prior to testing.

3.5.1.5 Sequence

The sequence of testing shall be as specified in the approved testing plan unless variance is authorized by the Contracting Officer. Field testing shall be performed in the presence of the Contracting Officer. Tests may be scheduled and sequenced in order to optimize run-time periods; however, the following general order of testing shall be followed: Construction

Tests; Inspections; Pre-operational Tests; Safety Run Tests; Performance Tests; and Final Inspection.

3.5.2 Construction Tests

Individual component and equipment functional tests for fuel piping, coolant piping, and lubricating-oil piping, electrical circuit continuity, insulation resistance, circuit protective devices, and equipment not provided by the engine-generator set manufacturer shall be performed prior to connection to the engine-generator set.

3.5.2.1 Piping Test

a. Lube-oil and fuel-oil piping shall be flushed with the same type of fluid intended to flow through the piping, until the outflowing fluid has no obvious sediment or emulsion.

b. Fuel piping which is external to the engine-generator set shall be tested in accordance with NFPA 30. All remaining piping which is external to the engine-generator set shall be pressure tested with air pressure at 150% of the maximum anticipated working pressure, but not less than 150 psi, for a period of 2 hours to prove the piping has no leaks. If piping is to be insulated, the test shall be performed before the insulation is applied.

3.5.2.2 Electrical Equipment Tests

a. Medium-voltage cable insulation integrity tests shall be performed for cables connecting the generator breaker to the generator switchgear. After installation and before the operating test or connection to an existing system, the medium-voltage cable system shall be given a high potential test. Direct-current voltage shall be applied on each phase conductor of the system by

connecting conductors as one terminal and connecting grounds of metallic shieldings or sheaths of the cable as the other terminal for each test. Prior to making the test, the cables shall be isolated by opening applicable protective devices and disconnecting equipment. The test shall be conducted with all splices, connectors, and terminations in place. The method, voltage, length of time, and other characteristics of the test for initial installation shall be in accordance with NEMA WC 74 for the particular type of cable installed, and shall not exceed the recommendations of IEEE Std 404 cable joints and IEEE Std 48 for cable terminations. Should any cable fail due to a weakness of conductor insulation or due to defects or injuries incidental to the installation or because of improper installation of cable, cable joints, terminations, or other connections, the Contractor shall make necessary repairs or replace cables as directed. Repaired or replaced cables shall be retested.

c. Ground-Resistance Tests. The resistance of each grounding electrode system shall be measured using the fall-of-potential method defined in IEEE Std 81. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. Readings shall be reported to Contracting Officer.

d. Circuit breakers and switchgear shall be examined and tested in accordance with the manufacturer's published instructions for functional testing.

3.5.3 Inspections

The following inspections shall be performed jointly by the Contracting Officer and the Contractor, after complete installation of each engine-generator set and its associated equipment, and prior to startup of the engine-generator set. Checks applicable to the installation shall be performed. The results of those which are physical inspections (I) shall be documented by the Contractor and submitted in accordance with paragraph SUBMITTALS. The Contractor shall present manufacturer's data for the inspections designated (D) at the time of inspection. Inspections shall verify that equipment type, features, accessibility, installation and condition are in accordance with the contract specification. Manufacturer's statements shall certify provision of features which cannot be verified visually.

1. Drive belts. (I)
2. Governor type and features. (I)
3. Engine timing mark. (I)
4. Starting motor. (I)
5. Starting aids. (I)
6. Coolant type and concentration. (D)
7. Radiator drains. (I)
8. Block coolant drains. (I)
9. Coolant fill level. (I)
10. Coolant line connections. (I)
11. Coolant hoses. (I)
12. Combustion air filter. (I)
13. Intake air silencer. (I)
14. Lube oil type. (D)
15. Lube oil sump drain. (I)
16. Lube-oil filter. (I)
17. Lube-oil level indicator. (I)
18. Lube-oil fill level. (I)
19. Lube-oil line connections. (I)
20. Lube-oil lines. (I)
21. Fuel type. (D)
22. Fuel-level. (I)
23. Fuel-line connections. (I)
24. Fuel lines. (I)
25. Fuel filter. (I)
26. Access for maintenance. (I)
27. Voltage regulator. (I)
28. Battery-charger connections. (I)
29. Wiring & terminations. (I)
30. Instrumentation. (I)
31. Hazards to personnel. (I)
32. Base. (I)
33. Nameplates. (I)
34. Paint. (I)
35. Exhaust-heat system. (I)
36. Exhaust muffler. (I)
37. Switchboard. (I)
38. Switchgear. (I)
39. Access provided to controls. (I)
40. Enclosure is weather resistant. (I)
41. Engine & generator mounting bolts (application). (I)

3.5.4 Pre-operational Tests

3.5.4.1 Protective Relays

Protective relays shall be visually and mechanically inspected, adjusted, tested, and calibrated in accordance with the manufacturer's published instructions. Tests shall include pick-up, timing, contact action, restraint, and other aspects necessary to ensure proper calibration and operation. Relay settings shall be implemented in accordance with the installation coordination study. Relay contacts shall be manually or electrically operated to verify that the proper breakers and alarms initiate. Relaying current transformers shall be field tested in accordance with IEEE C57.13.1.

3.5.4.2 Insulation Test

Generator and exciter circuits insulation resistance shall be tested in accordance with IEEE Std 43. Stator readings shall be taken at the circuit breaker, to include generator leads to switchgear. Results of insulation resistance tests shall be recorded. Readings shall be within limits specified by the manufacturer. Mechanical operation, insulation resistance, protective relay calibration and operation, and wiring continuity of switchgear assembly shall be verified. Precautions shall be taken to preclude damaging generator components during test.

3.5.5 Safety Run Test

For the following tests, if any parts are changed, or adjustments made to the generator set, its controls, or auxiliaries, the associated safety tests shall be repeated.

Perform and record engine manufacturer's recommended prestarting checks and inspections.

b. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

c. Activate the manual emergency stop switch and verify that the engine stops.

d. Remove the high and pre-high lubricating oil temperature sensing elements from the engine and temporarily install a temperature gauge in their normal locations on the engine (required for safety, not for recorded data). Where necessary provide temporary wiring harness to connect the sensing elements to their permanent electrical leads.

e. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period. Operate the engine-generator set at no load until the output voltage and frequency stabilize. Monitor the temporarily installed temperature gauges. If either temperature reading exceeds the value required for an alarm condition, activate the manual emergency stop switch.

f. Immerse the elements in a vessel containing controlled-temperature hot oil and record the temperature at which the pre-high alarm activates and the temperature at which the engine shuts down. Remove the temporary temperature gauges and reinstall the temperature sensors on the engine.

g. Remove the high and pre-high coolant temperature sensing elements from the engine and temporarily install a temperature gauge in their normal locations on the engine (required for safety, not for recorded data). Where necessary provide temporary wiring harness to connect the sensing elements to their permanent electrical leads.

h. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period. Operate the engine generator-set at no load until the output voltage and frequency stabilize.

i. Immerse the elements in a vessel containing controlled-temperature hot oil and record the temperature at which the pre-high alarm activates and the temperature at which the engine shuts down. Remove the temporary temperature gauges and reinstall the temperature sensors on the engine.

j. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

k. Operate the engine generator-set for at least 2 hours at 75% of Service Load.

l. Verify proper operation and setpoints of gauges and instruments.

m. Verify proper operation of ancillary equipment.

Manually adjust the governor to increase engine speed past the overspeed limit. Record the RPM at which the engine shuts down.

o. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 75% of Service Load.

p. Manually adjust the governor to increase engine speed to within 2% of the overspeed trip speed previously determined and operate at that point for 5 minutes. Manually adjust the governor to the rated frequency.

q. Manually fill the day tank to a level above the overfill limit. Record the level at which the overfill alarm sounds. Verify shutdown of the fuel transfer pump. Drain the day tank down below the overfill limit.

r. Shut down the engine. Remove the time-delay low lube oil pressure alarm bypass and try to start the engine.

s. Attach a manifold to the engine oil system (at the oil pressure sensor port) that contains a shutoff valve in series with a connection for the engine's oil pressure sensor followed by an oil pressure gauge ending with a bleed valve. The engine's oil pressure sensor shall be moved from the engine to the manifold. The manifold shutoff valve shall be open and bleed valve closed.

t. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 75% of Service Load.

u. Close the manifold shutoff valve. Slowly allow the pressure in the manifold to bleed off through the bleed valve while watching the pressure gauge. Record the pressure at which the engine shuts down. Catch oil spillage from the bleed valve in a container. Add the oil from the container back to the engine, remove the manifold, and reinstall the engine's oil pressure sensor on the engine.

v. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 100% of Service Load. Record the maximum sound level in each frequency band at a distance of 75 feet from the end of the exhaust and air intake piping directly along the path of intake and discharge for horizontal piping; or at a radius of 75 feet from the engine at 45 degrees apart in all directions for vertical piping. If a sound limiting enclosure is provided, the enclosure, the muffler, and intake silencer shall be modified or replaced as required to meet the sound requirements contained within this specification

w. Manually drain off fuel slowly from the day tank to empty it to below the low fuel level limit and record the level at which the audible alarm sounds. Add fuel back to the day tank to fill it above low level alarm limits.

3.5.6 Performance Tests

In the following tests, where measurements are to be recorded after stabilization of an engine-generator set parameter (voltage, frequency, current, temperature, etc.), stabilization is considered to have occurred when measurements are maintained within the specified bandwidths or tolerances, for a minimum of four consecutive readings. For the following tests, if any parts are changed, or adjustments made to the generator set, its controls, or auxiliaries, the associated tests shall be repeated.

3.5.6.1 Continuous Engine Load Run Test

Test the engine-generator set and ancillary systems at service load to demonstrate durability; verify that heat of extended operation does not adversely affect or cause failure in any part of the system; and check all parts of the system. If the engine load run test is interrupted for any reason, the entire test shall be repeated. After each change in load in the following test, measure the vibration at the end bearings (front and back of engine, outboard end of generator) in the horizontal, vertical, and axial directions. Verify that the vibration is within the allowable range. Data taken at 15 minute intervals shall include the following:
Electrical: Output amperes, voltage, real and reactive power, power factor, frequency.

Pressure: Lube-oil.

Temperature: Coolant.
Lube-oil.
Exhaust.
Ambient.

a. Perform and record engine manufacturer's recommended prestarting checks and inspections. Include as a minimum checking of coolant fluid, fuel, and lube-oil levels.

b. Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warmup period.

c. Operate the engine generator-set for 2 hours at 75% of Service Load.

d. Increase load to 100% of Service Load and operate the engine generator-set for 4 hours.

e. Remove load from the engine-generator set.

3.5.6.2 Voltage and Frequency Droop Test

For the following steps, verify that the output voltage and frequency return to and stabilize within the specified bandwidth values following each load change. Record the generator output frequency and line-line and line-neutral voltages following each load change.

a. With the generator operating at no load, adjust voltage and frequency to rated voltage and frequency.

b. Increase load to 100% of Rated Output Capacity. Record the generator output frequency and line-line and line-neutral voltages.

c. Calculate the percent droop for voltage and frequency with the following equations.

$$\text{Voltage droop \%} = \frac{\text{No-load volts - rated output capacity volts}}{\text{Rated output capacity volts}} \times 100$$

$$\text{Frequency droop \%} = \frac{\text{No load hertz - rated output capacity hertz}}{\text{Rated output capacity volts}} \times 100$$

d. Repeat steps a. through c. two additional times without making any adjustments.

3.5.6.3 Voltage Regulator Range Test

a. While operating at no load, verify that the voltage regulator adjusts from 90% to 110% of rated voltage.

b. Increase load to 100% of Rated Output Capacity. Verify that the voltage regulator adjusts from 90% to 110% of rated voltage.

3.5.6.4 Governor Adjustment Range Test

a. While operating at no load, verify that the governor adjusts from 90% to 110% of rated frequency.

b. Increase load to 100% of Rated Output Capacity. Verify that the governor adjusts from 90% to 110% of rated frequency.

3.5.6.5 Frequency and Voltage Stability and Transient Response

Verify that the engine-generator set responds to addition and dropping of blocks of load in accordance with the transient response requirements. Document maximum voltage and frequency variation from bandwidth and verify that voltage and frequency return to and stabilize within the specified bandwidth, within the specified response time period. Document results in tabular form and with high resolution, high speed strip chart recorders or comparable digital recorders, as approved by the Contracting Officer.

Tabular data shall include the following:

(1) Ambient temperature (at 15 minute intervals).
(2) Generator output current (before and after load changes).
(3) Generator output voltage (before and after load changes).
(4) Frequency (before and after load changes).
(5) Generator output power (before and after load changes.
(6) Graphic representations shall include the actual instrument trace of voltage and frequency showing:

Charts marked at start of test; observed steady-state band; mean of observed band; momentary overshoot and undershoot (generator terminal voltage and frequency) and recovery time for each load change together with the voltage and frequency maximum and minimum trace excursions for each steady state load condition prior to and immediately following each load change. Generator terminal voltage and frequency transient recovery time for each step load increase and decrease.

a. Perform and record engine manufacturer's recommended prestarting checks and inspections.

b. Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period and no load. Verify stabilization of voltage and frequency within specified bandwidths.

c. With the unit at no load, apply the Maximum Step Load Increase.
d. Apply load in steps equal to the Maximum Step Load Increase until the addition of one more step increase will exceed the Service Load.

e. Decrease load to the unit such that addition of the Maximum Step Load Increase will load the unit to 100% of Service Load.

f. Apply the Maximum Step Load Increase.

g. Decrease load to zero percent in steps equal to the Maximum Step Load Decrease.

h. Repeat steps c. through g.

3.5.7 Parallel Operation Test

Test the capability of each engine-generator set to parallel and share load with other generator sets, individually and in all combinations. This test must be performed with the voltage regulator and governor adjustment settings used for the Frequency and Voltage Stability and Transient Response test. If settings are changed during the performance of this test, a voltage and frequency stability and transient response test must be performed for each engine generator set using the setting utilized in this test. During operations record load-sharing characteristics of each set in parallel operation. Data taken shall include the following:

(1) Ambient temperature (at 15 minute intervals).
(2) Generator output current (before and after load changes).
(3) Generator output voltage (before and after load changes).
(4) Power division and exchange between generator sets.
(5) Real power (watts) and reactive power (vars) on each set.

3.5.7.1 Combinations

Connect each set, while operating at no load, parallel with one other set

in the system, operating at service load, until all possible two-unit-in-parallel combinations have been achieved. Verify stabilization of voltage and frequency within specified bandwidths and proportional sharing of real and reactive loads. Document stabilization of voltage and frequency within specified bandwidth, the active power division, active power exchange, reactive power division, and voltage and frequency stability and transient response in the following steps for each combination.

a. Divide the load proportionally between the sets and operate in parallel for 15 minutes.

b. Increase the load, in steps equal to the Maximum Step Increase, until each set is loaded to its service load.

c. Decrease the load, in steps equal to the Maximum Step Decrease, until each set is loaded to approximately 25% of its service load.

d. Increase the load, in steps equal to the Maximum Step Increase, until each set is loaded to approximately 50% of its service load Verify stabilization of voltage and frequency within specified bandwidths and proportional sharing of real and reactive load.

e. Reduce the sum of the loads on both sets to the output rating of the smaller set.

f. Transfer a load equal to the output rating of the smaller of the 2 sets to and from each set. Verify stabilization of voltage and frequency within specified bandwidths and proportional sharing of real and reactive load.

g. Document the active power division, active power exchange, reactive power division, and voltage and frequency stability and transient response .

3.5.7.2 Multiple Combinations

Connect each set, while operating at no load, parallel with all multiple combinations of all other set in the system, while operating at service load, until all multiple combinations of parallel operations have been achieved.

3.5.8 Parallel Operation Test (Commercial Source)

Connect each set parallel with the commercial power source. Operate in parallel for 15 minutes. Verify stabilization of voltage and frequency within specified bandwidths. Record the output voltage, frequency, and loading to demonstrate ability to synchronize with the commercial power source.

3.5.9 Automatic Operation Tests for Multiple Engine Generator Set Parallel Operation In Standalone Mode

The automatic operating system shall be tested to demonstrate automatic starting, loading and unloading, the response to loss of operating engine-generator sets, and paralleling of each engine-generator set. The loads for this test shall utilize load banks at the indicated power factor and actual loads to be served, and the loading sequence shall be the indicated sequence. During all operations load-sharing characteristics

shall be recorded. Perform this test for a minimum of two successive, successful tests. Data taken shall include the following:

(1) Ambient temperature (at 15 minute intervals).
(2) Generator output current (before and after load changes).
(3) Generator output voltage (before and after load changes).
(4) Generator output frequency (before and after load changes).
(5) Power division and exchange between generator sets.
(6) Real and reactive power on each set.

a. Initiate loss of the preferred power source and verify the specified sequence of operation.

b. Verify resetting of automatic starting and transfer logic.

3.5.10 Automatic Operation Tests for Stand-Alone Operation

The automatic loading system shall be tested to demonstrate automatic starting of each engine-generator set. The loads for this test shall utilize the actual loads to be served, and the loading sequence shall be the indicated sequence. Perform this test for a minimum of two successive, successful tests. Data taken shall include the following:

(1) Ambient temperature (at 15 minute intervals).
(2) Generator output current (before and after load changes).
(3) Generator output voltage (before and after load changes).
(4) Generator output frequency (before and after load changes).

a. Initiate loss of the primary power source and verify automatic sequence of operation.

b. Restore the primary power source and verify sequence of operation.

c. Verify resetting of controls to normal.

3.5.11 Final Testing and Inspection

a. Start the engine, record the starting time, make and record all engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

b. Increase the load in steps no greater than the Maximum Step Load Increase to 100% of Service Load, and operate the engine-generator set for at least 30 minutes. Measure the vibration at the end bearings (front and back of engine, outboard end of generator) in the horizontal, vertical, and axial directions. Verify that the vibration is within the same range as previous measurements and is within the required range.

c. Remove load and shut down the engine-generator set after the recommended cool down period.

d. Remove the lube oil filter and have the oil and filter examined by the engine manufacturer for excessive metal, abrasive foreign particles, etc. Any corrective action shall be verified for effectiveness by running the engine for 8 hours at Service Load, then re-examining the oil and filter.

e. Remove the fuel filter and examine the filter for trash, abrasive foreign particles, etc.

f. Visually inspect and check engine and generator mounting bolts for tightness and visible damage.

g. Replace air, oil, and fuel filters with new filters.

3.6 POSTED DATA AND INSTRUCTIONS

Posted Data and Instructions shall be posted prior to field acceptance testing of the engine generator set. Two sets of instructions/data shall be typed and framed under weatherproof laminated plastic, and posted side-by-side where directed. First set shall include a one-line diagram, wiring and control diagrams and a complete layout of the system. Second set of shall include the condensed operating instructions describing manufacturer's pre-start checklist and precautions; startup procedures for test-mode, manual-start mode, and automatic-start mode (as applicable); running checks, procedures, and precautions; and shutdown procedures, checks, and precautions. Instructions shall include procedures for interrelated equipment (such as heat recovery systems, co-generation, load-shedding, and automatic transfer switches).

3.7 ONSITE TRAINING

The Contractor shall conduct training course for operating staff as designated by the Contracting Officer. The training period shall consist of a total 40 hours of normal working time and shall start after the system is functionally completed but prior to final acceptance. All operation and maintenance manuals shall bee approved and made available for the training course. All posted instructions shall be approved and posted prior to the beginning date of the training course. The training course schedule shall be coordinated with the Using Service's work schedule, and submitted for approval 14 days prior to beginning date of proposed beginning date of training. The course instructions shall cover pertinent points involved in operating, starting, stopping, servicing the equipment, as well as major elements of the operation and maintenance manuals. Additionally, the course instructions shall demonstrate routine maintenance procedures as described in the operation and maintenance manuals. Two copies of a video tape of the entire training session shall be submitted.

3.8 ACCEPTANCE

Final acceptance of the engine-generator set will not be given until the Contractor has successfully completed all tests and all defects in installation material or operation have been corrected.

-- End of Section --

SECTION 16265
UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM ABOVE 15 KVA CAPACITY
04/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C57.110 (1998) Recommended Practice for Establishing Transformer Capability When Supplying Nonsinusoidal Load Currents

IEEE C62.41 (1991; R 1995) Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits

IEEE Std 450 (2002) Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications

IEEE Std 485 (1997) Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA PE 1 (2003) Uninterruptible Power Systems -- Specification and Performance Verification NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2005) National Electrical Code

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

UPS System; G

Installation; G

Detail drawings consisting of a complete list of equipment and materials, manufacturer's descriptive and technical literature, battery sizing calculations per IEEE Std 485, installation instructions, single-line diagrams, ladder-type schematic diagrams, elevations, layout drawings, and details required to demonstrate that the system has been coordinated and will function properly as a unit.

SD-03 Product Data

Performance Requirements

Pertinent performance data for the UPS system, using a copy of the data sheets supplied with this specification. Data sheets shall be certified by a responsible officer of the UPS manufacturer.

Spare Parts

Spare parts data, as specified.

Field Training; G

Lesson plans and training manuals for the training phases, including type of training to be provided and proposed dates, with a list of reference materials.

SD-06 Test Reports

Factory Testing; G

Field Supervision, Startup and Testing; G

A detailed description of proposed factory test and field test procedures, including proposed dates and steps outlining each test, how it is to be performed, what it accomplishes, and its duration, not later than one month prior to the date of each test. Factory and field test reports in booklet form tabulating factory and field tests and measurements performed, upon completion and testing of the installed system. Factory and field test reports shall be signed by an official authorized to certify on behalf of the manufacturer of the UPS system that the system meets specified requirements. The reports shall be dated after the award of this contract, shall state the Contractor's name and address, shall name the project and location, and shall list the specific requirements which are being certified.

1.3 SYSTEM DESCRIPTION

The UPS system shall consist of UPS module, battery system, battery protective device, system cabinet, static bypass transfer switch, controls and monitoring. Input ac power shall be connected to the normal source ac input of the UPS module. The battery shall be connected to the dc input of the UPS module through the battery protective device. The ac output of the UPS system shall be connected to the critical loads.

1.3.1 UPS Module and Battery System

UPS module shall contain required input isolation transformer, rectifier/charger unit, inverter unit and controls, battery protective device, and any other specified equipment/devices. Battery system shall contain the battery cells, racks, battery disconnect, battery monitor and cabinet, if required.

1.3.2 Cabinet, Static Bypass Transfer Switch, Control and Monitoring
The UPS system shall include the system cabinet, static bypass transfer switch, system protective devices, monitoring and controls, means of isolating the system from the critical load, and remote monitoring interfaces.

1.3.2 Design Requirements

1.3.2.1 Parts and Materials

Parts and materials comprising the UPS system shall be new, of current manufacture, of a high grade and free of defects and imperfections, and shall not have been in prior service except as required during aging and factory testing.

1.3.3.2 Components

Active electronic devices shall be solid state. Semiconductor devices shall be sealed. Relays shall be dust-tight.

1.3.3.3 Semiconductor Fusing

Power semiconductors shall be fused to prevent cascaded or sequential semiconductor failures. Indicator lamp denoting blown fuse conditions shall be readily observable by the operator without removing panels or opening cabinet doors.

1.3.3.4 Interchangeability

The subassemblies in one UPS module shall be interchangeable with the corresponding modules within the same UPS, and from one UPS system to another of identical systems.

1.3.3.5 Control Power

Control power shall be derived from two sources, input and output, with automatic selective control. The control power circuit shall have suitable protection, appropriately marked and located in the immediate vicinity of the input protective device.

1.3.3.6 EMI/RFI Protection

The components and the system shall be designed to minimize the emission of electromagnetic waves that may cause interference with other equipment.

1.3.3.7 Wiring

Wiring practices, materials, and coding shall be in accordance with the requirements of NFPA 70 and other applicable standards. Wire runs shall be protected in a manner which separates power and control wiring. Control wiring shall be minimum No. 16 AWG extra-flexible stranded copper. Logic-circuit wiring may be smaller. Ribbon cables shall be minimum No. 22 AWG. Control wiring shall have permanently attached wire numbers.

1.3.3.8 Terminations

Terminals shall be supplied for making power and control connections.

Terminal blocks shall be provided for field wiring terminals. Terminal blocks shall be heavy-duty, strap-screw type. Terminal blocks for field wiring shall be located in one place in each module and in the system cabinet. Control wiring shall be extended to the terminal block location. No more than two wires shall land on any terminal point. Where control wiring is attached to the same point as power wiring, a separate terminal shall be provided. If bus duct is used, bus stubs shall be provided where bus duct enters cabinets.

1.3.3.9 Internal Assembly

The subassemblies shall be mounted in pull-out and/or swing-out trays where feasible. Cable connections to the trays shall be sufficiently long to allow easy access to all components. Where not feasible to mount subassemblies in pull-out or swing-out trays, they shall be firmly mounted inside the enclosure. Test points or logic indicators shall be labeled and located on the front edge of the control logic cards, if used.

1.3.3.10 Cabinet Structure

UPS system shall be installed in cabinets of heavy-duty structure meeting the NEMA PE 1 standards for floor mounting. UPS module cabinet shall be structurally adequate for forklift handling or lifting. Removable lifting eyes shall be provided on top of each cabinet. UPS module cabinet shall have hinged and lockable doors on the front only, with assemblies and components accessible from the front. Doors shall be key lockable. Operating controls shall be located outside the locked doors. Input, output, and battery cables shall be installed through the top or bottom of the cabinet.

1.3.3.11 Cabinet Finish

Equipment cabinet shall be cleaned, primed and painted in the manufacturer's standard colors, in accordance with accepted industry standards.

1.3.3.12 Mimic Bus

Mmimic bus and other front-panel markings (such as those showing circuit breakers or switches and fuses) shall be Phenolic of contrasting color to the system.

1.3.3.13 Live Parts (300 Volts and Above)

Live parts (300 volts and above) that are exposed when front access doors are open shall be adequately protected or covered to minimize the chance of accidental contact.

1.3.3.14 Drawout Assemblies

Drawout assemblies weighing 50 lbs or more shall be provided with a means of lifting, either an overhead device or a hoisting device.

1.3.3.15 Safety

UPS shall be equipped with instruction plates including warnings and cautions, suitably located, describing any special or important procedures to be followed in operating and servicing the equipment.

1.3.3 Performance Requirements

1.3.4.1 Normal Operation

The UPS module rectifier/charger shall convert the incoming ac input power to dc power for the inverter and for float charging the battery. The inverter shall supply ac power continuously. Inverter output shall be synchronized with the bypass ac power source, provided that the bypass ac power source is within the specified frequency range. The UPS system shall supply ac power to the critical loads.

1.3.4.2 Loss of ac Input Power

The battery shall supply dc power to the inverter so that there is no interruption of ac power to the critical load whenever the ac input power source deviates from the specified tolerances or fails completely. The battery shall continue to supply power to the inverter for the specified protection time. At the same time, an alarm shall sound to alert operating personnel, allowing startup of a secondary power source or orderly shutdown of the critical load.

1.3.4.3 Return of ac Input Power Source

The rectifier/charger shall start and assume the dc load from the battery when the ac input power source returns. The rectifier/charger shall then simultaneously supply the inverter with dc power and recharge the battery. This shall be an automatic function and shall cause no disturbance to the critical load.

1.3.4.4 Failure of ac Input Power to Return

Should the ac input power fail to return before the battery voltage reaches the discharge limit, the UPS system shall disconnect from the critical load to safeguard the battery.

1.3.4.5 Failure of a Module

In a redundant configuration, failure of one module shall cause that module to be disconnected from the system critical load bus by its internal protective devices and its individual output protective device. The remaining module shall continue to carry the load. Upon restoration of the failed module, it shall be possible to reconnect the failed module to the critical load bus to resume redundant operation without disruption of the critical load.

1.3.4.6 Transfer to Bypass ac Power Source

When the static bypass switch senses an overload, two or more inverter shutdown signals, or degradation of the inverter output, the bypass switch shall automatically transfer the critical load from the inverter output to the bypass ac power source without an interruption of power only if the connected load exceeds the capacity of the remaining on-line modules. If the bypass ac power source is out of normal tolerance limits, the UPS and the critical load shall shut down.

1.3.4.7 Retransfer to Inverter

The static bypass switch shall be capable of automatically retransferring the load back to the inverter output after the inverter output has returned to normal conditions. Retransfer shall not occur if the two sources are not synchronized.

1.3.4.8 UPS Module Maintenance

UPS modules shall be capable of manual disconnection from the critical load bus for maintenance without disturbing the critical load bus.

1.3.4.9 UPS System Maintenance

Manual closure of the maintenance bypass switch shall transfer the critical load from the inverter output to the bypass ac power source without disturbing the critical load bus. UPS module shall be capable of manual return to normal operation after completion of maintenance.

1.3.4.10 Battery Maintenance

The battery protective device shall provide the means of disconnecting the battery from the rectifier/charger and inverter for maintenance. The UPS module shall continue to function and meet the performance criteria specified except for the battery function.

1.4 QUALITY ASSURANCE

1.4.1 Reliability

UPS shall have a minimum acceptable system Mean Time Between Failures (MTBF) of 25,000 hours. A failure is defined as any interruption to or degradation of the UPS output. Automatic switching to bypass due to a problem with the UPS system does not constitute a failure, provided that the critical load is not disturbed.

1.4.2 Maintainability

UPS shall have a maximum acceptable system Mean Time To Repair (MTTR) of 30 minutes. Repair time is defined as the clock time from the arrival of the service technician to the time when the UPS is restored to service either by repair or substitution of the failed component.

1.5 DELIVERY AND STORAGE

Equipment placed in storage shall be protected from humidity and temperature variations, dirt, dust, or other contaminants.

1.6 PROJECT/SITE CONDITIONS

1.6.1 Environmental Conditions

The UPS and battery system shall be capable of withstanding any combination of the following external environmental conditions without mechanical or electrical damage or degradation of operating characteristics.

a. Operating altitude: Sea level to 4,000 feet. (Systems applied at higher altitudes shall be derated in accordance with the manufacturer's instructions).

b. Non-operating altitude: Sea level to 40,000 ft.

c. Operating ambient temperature range: 32 to 122 degrees F.

d. Non-operating and storage ambient temperature range: Minus 4 to plus 140 degrees F.

e. Operating relative humidity: 0 to 95 percent, without condensation.

1.6.2 Sound Pressure Levels

Sound pressure levels produced by the UPS, when operating under full rated load, at a distance of 5 feet in any direction from the perimeter of the unit, shall not exceed 70 dB as measured on the A scale of a standard sound level meter at slow response.

1.6.3 Verification of Dimensions

The Contractor shall become familiar with details of the work, verify dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing the work.

1.7 NAME PLATES

Each major item of equipment shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment.

1.8 SPECIAL TOOLS

One set of special tools, calibration devices, and instruments required for operation, calibration, and maintenance of the equipment shall be provided.

1.8 OPERATION AND MAINTENANCE MANUALS

Six complete copies of operation manuals for the UPS System outlining the step-by-step procedures required for system startup, operation and shutdown shall be provided. The instructions shall include the manufacturer's name, equipment model number, service manual, parts list, and brief description of equipment and its basic operational features. Six complete copies of maintenance manuals listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides shall be provided. Corrective maintenance procedures shall identify the most probable failures and the appropriate repairs. Test measurement levels shall be referenced to specific test points on the installed equipment. Operation and maintenance manuals may be either combined or separate.

1.9 SPARE PARTS

The Contractor shall submit spare parts data for each different item of material and equipment specified, not later than the date of beneficial occupancy. The data shall include a complete list of parts and supplies with current unit prices and source of supply and an itemized price breakdown of spare parts recommended for stocking. The recommended spare parts selected shall be those which, in the manufacturer's judgment, will be involved in the majority of maintenance difficulties encountered.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Materials and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of such products and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

2.2 LOAD PROFILE

The UPS system shall be compatible with the load characteristics defined in the LOAD PROFILE TABLE below and load configuration shown. Compensation for UPS/load interaction problems resulting from nonlinear loads or transformer and motor inrush shall be provided.

LOAD PROFILE TABLE FOR EACH OF THE THREE OPS BUILDING UPS SYSTEM

Type of load: Electronic equipment and data processing

Size of load: 2.7 MW at 0.9 lagging power factor

Switching pattern: Unswitched

Transient characteristics: Unswitched

Steady-state characteristics: 0.9 lagging to 0.9 leading power factor

LOAD PROFILE TABELE FOR ANTENNA FARM BUILDING

Type of Load Electronic equipment and data processing

Size of Load 135 kW

Switching Pattern Unswitched

Transient Characteristics Unswitched

Steady-State Characteristics 0.9 lagging to 0.9 leading power factor

2.3 UPS SYSTEM RATINGS

Unless stated otherwise, the parameters listed are under full output load at 0.9 power factor, with batteries fully charged and floating on the dc bus and with nominal input voltage.

2.3.1 System Capacity

a. Overall 3,000 kVA, 2,700 kW, N+1 redundant, at 40 degrees C for OPS building.

b. Overall 150 kVA, 135 kW, N+1 redundant, at 40 degrees C for Antenna Farm.

2.3.2 Module Capacity

a. 750 kVA, 675 kW for OPS building.

b. 150 kVA, 135 kW for Antenna Farm.

2.3.3 Battery Capacity

Discharge time to end voltage: 20 minutes, at 77 degrees F. Battery shall be capable of delivering 125 percent of full rated UPS load at initial start-up.

2.3.4 Static Switch

a. 4,000 amperes, amperes symmetrical interrupting capacity for OPS building, 200 amperes, 15,000 amperes symmetrical interrupting capacity.

2.3.5 System Bus Bracing

Braced for 65,000 amperes symmetrical interrupting capacity for all systems.

2.3.6 ac Input

a. Voltage 480 volts line-to-line.

b. Number of phases: 3-phase, 3-wire, plus ground.

c. Voltage Range: Plus 10 percent, minus 15 percent, without affecting battery float voltage or output voltage.

d.Frequency: 60 Hz, plus or minus 5 percent.

e. Power walk-in: 20 percent to 100 percent over 15 to 24 seconds.

f. Total harmonic current distortion (THD) reflected into the primary line: 5 percent maximum.

g. Transformer sub-cycle inrush: 4 to 8 times full load rating.

2.3.7 ac Output

a. Voltage 480 volts line-to-line, 277 volts line-to-neutral.

b. Number of phases: 3-phase, 4-wire, plus ground.

c. Voltage regulation:

(1) Balanced load: Plus or minus 1.0 percent.

(2) 50 percent load imbalance, phase-to-phase: Plus or minus 2 percent.

(3) No-load voltage modulation: Plus or minus 1 percent.

(4) Voltage drift: Plus or minus 1 percent over any 30 day interval at stated ambient conditions.

d. Voltage adjustment: Plus or minus 5 percent manually.

e. Frequency: 60 Hz.

f. Frequency regulation: Plus or minus 0.1 percent.

g. Frequency drift: Plus or minus 0.1 percent over any 24 hour interval at stated ambient conditions when on internal oscillator.

h. Harmonic content (RMS voltage): 2 percent single harmonic, maximum; 4 percent total maximum with linear load. Voltage THD shall be less than 5 percent with up to 50 percent nonlinear load and a crest factor of less than 3 to 1.

i. Load power factor operating range: 1.0 to 0.8 lagging.

j. Phase displacement:

(1) Balanced load: Plus or minus 1 degree of bypass input.

(2) 50 percent load imbalance phase-to-phase: Plus or minus 3 degrees of bypass input.

k. Wave-form deviation factor: 5 percent at no load.

l. Overload capability (at full voltage) (excluding battery):

(1) 125 percent load for 10 minutes.

(2) 150 percent load for 30 seconds.

(3) 300 percent load for one cycle after which it shall be current limited to 150 percent until fault is cleared or UPS goes to bypass.

m. Load sharing of parallel modules: Plus or minus 5 percent of average load per module.

2.3.8 Transient Response

2.3.8.1 Voltage Transients

a. 50 percent load step/0 percent to 50 percent load: Plus or minus 8 percent.

b. 50 percent load step/50 percent to 100 percent load: Plus or minus 8 percent.

c. Loss or return of ac input: Plus or minus 1 percent.

d. Loss or return of redundant module:

(1) Manually: Plus or minus 5 percent.

(2) Automatically: Plus or minus 5 percent.

e. Automatic transfer of load from UPS to bypass: Plus or minus 4 percent.

f. Manual retransfer of load from bypass to UPS: Plus or minus 4 percent.

g. Response time: Recovery to 99 percent steady-state condition within 50 milliseconds after any of the above transients.

2.3.8.2 Frequency

a. Transients: Plus or minus 0.5 Hz maximum.

b. Slew Rate: 1.0 Hz maximum per second.

2.3.9 Efficiency

a. Minimum Single-Module Efficiency: 92 percent at full load kW.

b. Minimum System Efficiency: 89 percent at full system load kW.

2.4 UPS MODULE

2.4.1 General Description

UPS module shall consist of a rectifier/charger unit and a 3-phase inverter unit with their associated transformers, synchronizing equipment, protective devices and accessories as required for operation.

2.4.2 Rectifier/Charger Unit

Rectifier/charger unit shall be solid state and shall provide direct current to the dc bus.

2.4.2.1 Input Protective Device

Rectifier/charger unit shall be provided with an input protective device. The protective device shall be sized to accept simultaneously the full-rated load and the battery recharge current. The protective device shall be capable of shunt tripping and shall have 50,000 amperes symmetrical interrupting capacity. The protective device shall have provision for locking in the "off" position. A surge suppression device shall be installed at the UPS input to protect against lightning and switching surges.

2.4.2.2 Power Transformer

A dry-type, isolated-winding power transformer shall be used for the rectifier unit. The transformer's hottest spot winding temperature shall not exceed the temperature limit of the transformer insulation material when operating at full load. The transformer insulation shall be Class H, 150 degrees C rise. Transformer connections shall be accessible from the front.

2.4.2.3 Power Walk-In

Rectifier/charger unit shall be protected by a power walk-in feature such that when ac power is returned to the ac input bus, the total initial power requirement will not exceed 20 percent of the rated full load current. This demand shall increase gradually to 100 percent of the rated full load current plus the battery charging current over the specified time interval.

2.4.2.4 Sizing

Rectifier/charger unit shall be sized for the following two simultaneous operating conditions:

a. Supplying the full rated load current to the inverter.

b. Recharging a fully-discharged battery to 95 percent of rated ampere-hour capacity within ten times the discharge time after normal ac power is restored, with the input protective device closed.

2.4.2.5 Battery Charging Current

a. Primary current limiting: Battery-charging current shall be voltage regulated and current limited. The battery-charging current limit shall be separately adjustable from 2 percent to 25 percent of the maximum discharge current. After the battery is recharged, the rectifier/charger unit shall maintain the battery at full float charge until the next operation under input power failure. Battery charger shall be capable of providing equalizing charge to the battery.

b. Second step current limiting: The rectifier/charger unit shall also have a second-step battery current limit. This second-step current limit shall sense actual battery current and reduce the input power demand for battery recharging to 50 percent (adjustable from 30 percent to 70 percent) of the normal rate without affecting the system's ability to supply full-rated power to the connected load. The second-step current-limit circuit shall be activated by a dry contact signal from the generator set controls and shall prevent normal rate battery recharging until utility power is restored.

2.4.2.6 Output Filter

Rectifier/charger unit shall have an output filter to minimize ripple current supplied to the battery; the ripple current into the battery shall not exceed 3 percent RMS.

2.4.2.7 dc Voltage Adjustment

Rectifier/charger unit shall have manual means for adjusting dc voltage for battery equalization, to provide voltage within plus 10 percent of nominal float voltage.

2.4.2.8 Battery Isolation Protective Device

Module shall have a dc protective device to isolate the module from the battery system. The protective device size and interrupting rating shall be as required by system capacity and shall incorporate a shunt trip as required by circuit design. The protective device shall have provision for locking in the "off" position.

2.4.3 Inverter Unit

Inverter unit shall be a solid-state device capable of accepting power from the dc bus and providing ac power within specified limits.

2.4.3.1 Output Overload

The inverter shall be able to sustain an overload as specified across its output terminals. The inverter shall not shut off, but shall continue to operate within rated parameters, with inverse-time overload shutdown protection.

2.4.3.2 Synchronism

The inverter shall normally operate in phase-lock and synchronism with the bypass source. Should the bypass source frequency deviate beyond 60 Hz by more than 0.5 Hz, the internal frequency oscillators contained in the power module shall be used to derive the new frequency reference. Upon restoration of the bypass source within the required tolerance, the inverter shall resynchronize with that source at a slew rate not exceeding the specified rate. The oscillator shall be temperature compensated and shall be manually adjustable. The design of the oscillator and synchronizing circuits shall be such that failure of any associated component, connector pin, terminal lead wire or dc power source in either the open or shorted mode shall affect only one inverter leg. Such failure shall not cause transient disturbance of the critical load in excess of the stated limits.

2.4.3.3 Phase Balance

Electronic controls shall be incorporated to provide individual phase voltage compensation to obtain phase balance.

2.4.3.4 Modular Construction

Each control logic printed circuit board shall be electrically and physically packaged on an individual plug-in module with separate indication and adjustments.

2.4.3.5 Output Protective Device

The output protective device shall be capable of shunt tripping and shall have interrupting capacity as specified. Protective device shall have provision for locking in the "off" position.

2.4.3.6 Output Transformer

The inverter output transformer shall be similar to the input transformer and shall be capable of handling up to K-13 nonlinear loads as described in IEEE C57.110.

2.4.3.7 Modular Inverter Isolation

Each inverter in the UPS system shall have fault sensing and static isolation as well as an output protective device, to remove a faulted module from the system without affecting the critical load bus beyond the stated limits.

2.4.4 External Protection

UPS module shall have built-in self-protection against undervoltage, overvoltage, overcurrent and surges introduced on the ac input source and/or the bypass source. The UPS system shall sustain input surges without damage in accordance with IEEE C62.41. The UPS shall also have built-in self-protection against overvoltage and voltage surges introduced at the output terminals by paralleled sources, load switching, or circuit breaker operation in the critical load distribution system.

2.4.5 Internal Protection

UPS module shall be self-protected against overcurrent, sudden changes in output load and short circuits at the output terminals. UPS module shall be provided with output reverse power detection which shall cause that module to be disconnected from the critical load bus when output reverse power is present. UPS module shall have built-in protection against permanent damage to itself and the connected load for predictable types of failure within itself and the connected load. At the end of battery discharge limit, the module shall shut down without damage to internal components.

2.4.6 Parallel Operation

For parallel operation, the protection system shall have control logic capable of isolating only the faulted module, and shall not shut down the entire UPS system upon a fault in one module. Open protective devices shall be indicated by an alarm and indicator light.

2.5 STATIC BYPASS TRANSFER SWITCH

A static bypass transfer switch shall be provided as an integral part of the UPS and shall consist of a static switch and a bypass protective device or bypass switch. The control logic shall contain an automatic transfer circuit that senses the status of the inverter logic signals and alarm conditions and provides an uninterrupted transfer of the load to the bypass ac power source, without exceeding the transient limits specified herein, when a malfunction occurs in the UPS or when an external overload condition occurs. The power section of the static bypass transfer switch shall be provided as a plug-in type assembly to facilitate maintenance. The static bypass transfer switch shall be used to connect the bypass ac power source or the UPS inverter output to the critical load when required, and shall have the following features:

2.5.1 Uninterrupted Transfer

The static bypass transfer switch shall automatically cause the bypass ac power source to assume the critical load without interruption when the bypass control logic senses one of the following conditions and the UPS inverter output is synchronized to the bypass ac power source:

a. Inverter overload exceeds unit's rating.

b. Battery protection period is expired and bypass is available.

c. Inverter failure.

2.5.2 Interrupted Transfer

If an overload occurs and the UPS inverter output is not synchronized to the bypass ac power source, the UPS inverter output shall current-limit for 200 milliseconds minimum. The inverter shall then turn off and an interrupted transfer to the bypass ac power source shall be made. If the bypass ac power source is beyond the conditions stated below, an interrupted transfer shall be made upon detection of a fault condition:

a. Bypass voltage greater than plus or minus 10 percent from the UPS rated output voltage.

b. Bypass frequency greater than plus or minus 0.5 Hz from the UPS rated output frequency.

c. Phase differential of ac bypass voltage to UPS output voltage greater than plus or minus 3 degrees.

2.5.3 Manual Transfer

It shall be possible to make a manually-initiated static transfer from the system status and control panel by turning the UPS inverter off.

2.5.4 Automatic Uninterrupted Forward Transfer

The static bypass transfer switch shall automatically forward transfer, without interruption after the UPS inverter is turned "on", or after an instantaneous overload-induced reverse transfer has occurred and the load current has returned to less than the unit's 100 percent rating.

2.5.5 Forced Transfer

The control logic circuitry shall provide the means of making a forced or reverse transfer of the static bypass transfer switch on an interrupted basis. Minimum interruption shall be 200 milliseconds when the UPS inverter is not synchronized to the bypass ac power source.

2.5.6 Overload Ratings

The static bypass transfer switch shall withstand the following overload conditions:

a. 2000 percent of UPS output rating for two cycles.

b. 200 percent of UPS output rating for 5 minutes.

c. 125 percent of UPS output rating for 10 minutes.

2.5.7 Static Switch Disconnect

A static switch disconnect shall be incorporated to isolate the static bypass transfer switch assembly so it can be removed for servicing. The switch shall be equipped with auxiliary contacts and provision for padlocking in either the "on" or "off" position.

2.6 MAINTENANCE BYPASS SWITCH

2.6.1 General

2.6.2 Load Transfer

The maintenance bypass switch shall provide the capability of transferring the critical load from the UPS static bypass transfer switch to maintenance bypass and then back to the UPS static bypass transfer switch with no interruption to the critical load.

2.6.3 Load Bank Protective Device

A load bank protective device shall be provided to allow the UPS system to

be tested using a portable load bank.

2.7 MODULE CONTROL PANEL

The UPS module shall be provided with a control/indicator panel. The panel shall be on the front of the UPS module. Controls, meters, alarms and indicators for operation of the UPS module shall be on this panel.

2.7.1 Module Meters

2.7.1.1 Monitored Functions

The following functions shall be monitored and displayed:

a. Input voltage, phase-to-phase (all three phases).

b. Input current, all three phases.

c. Input frequency.

d. Battery voltage at rectifier output.

e. Battery current (charge/discharge) at rectifier output.

f. Output voltage, phase-to-phase and phase-to-neutral (all three phases).

g. Output current, all three phases.

h. Output frequency.

i. Output kilowatts.

j. Elapsed time meter to indicate hours of operation, 6 digits.

k. Bypass voltage, phase-to-phase and phase-to-neutral (all three phases).

l. Output kilovars.

m. Output kilowatt hours, with 15-minute demand attachment.

n. Bypass input frequency.

o. Elapsed time discharging battery

p. DC charging system voltage

q. DC charging system ammeter.

2.7.1.2 Meter Construction

Meters shall have 1 percent accuracy and shall be digital type (minimum 4 significant digits).

2.7.2 Module Controls

Module shall have the following controls:

a. Lamp test/reset pushbutton.

b. Alarm test/reset pushbutton.

c. Module input protective device trip pushbutton, with guard.

d. Module output protective device trip pushbutton, with guard.

e. Battery protective device trip pushbutton, with guard.

f. Emergency off pushbutton, with guard.

g. dc voltage adjustment potentiometer, with locking guard.

h. Control power off switch.

i. UPS/bypass transfer selector switch.

j. Static bypass transfer switch enable/disable selector switch.

2.7.3 Module Alarm Indicators

Module shall have indicators for the following alarm items. Any one of these conditions shall turn on an audible alarm and the appropriate summary indicator. Each new alarm shall register without affecting any previous alarm.

a. Input ac power source failure.

b. Input protective device open.

c. Output protective device open.

d. Overload.

e. Overload shutdown.

f. dc overvoltage.

g. dc ground fault.

h. Low battery.

i. Battery discharged.

j. Battery protective device open.

k. Blower failure.

l. Input transformer overtemperature.

m. Inverter transformer overtemperature.

n. Equipment overtemperature.

o. Operating on internal oscillator.

p. Fuse blown.

Control power failure.

r. Charger off.

s. Inverter off.

t. Emergency off.

u. UPS on battery.

v. Critical load on static bypass.

w. Static bypass transfer switch disabled.

x. Inverter output overvoltage.

y. Inverter output undervoltage.

z. Inverter output overfrequency.

aa. Inverter output underfrequency.

2.7.4 Module Mimic Panel

UPS module shall have a mimic panel in the format of a module single-line diagram, with status indicators for input, output, battery protective devices, and battery disconnect switch. Each protective device shall have indicators for open (green) and closed (red), to give positive indication. The mimic panel shall provide indication of the following additional functions:

a. Charger on (functional).

b. UPS on-line (inverter furnishing load power).

c. UPS on-bypass (static switch operating).

d. System alarm (flashes for abnormalities, minor or major faults).

2.7.5 Module Emergency Off Button

Pressing the emergency off button shall cause the affected module to be disconnected from the system, via its input protective device, output protective device, and battery protective device. Activation of this button shall not affect the operation of the remainder of the system.

2.8 SYSTEM CONTROL CABINET

2.8.1 General Description

The multi-module UPS system shall be provided with a separate control cabinet for system output, summary monitoring, and control. This unit shall contain; bus bar connections to collect the output from each module, the static switch and its bypass breaker, the UPS system output protective device, and the UPS output switchgear.

2.8.2 UPS Output Switchgear

UPS Output switchgear configuration shall be as indicated on one-line diagrams, and in accordance with Specification 16442 SWITCHBOARDS AND SWITCHGEAR.

2.8.2.1 Interlocking

The main protective device and the load bank protective device shall be interlocked to prevent both being closed at the same time. The maintenance bypass protective device shall be interlocked with the UPS system output protective device and the static bypass switch. The maintenance bypass protective device shall not be capable of closing until the static bypass switch is closed and the UPS system output protective device is open. Once the maintenance bypass protective device is closed, the UPS output switchgear main protective device shall be capable of opening to isolate the critical loads from the UPS output. The load bank protective device as well as the UPS system output protective device shall then be capable of closing to permit load bank testing.

2.8.3 System Control Panel

A separate control panel shall be provided for the overall UPS system. The panel shall be on the front surface of the system cabinet. The controls, meters, alarms and indicators for operation of the UPS system shall be on this panel.

2.8.3.1 System Meters

Meters shall have 1 percent accuracy and shall be digital type (minimum 4 significant digits). ac voltages shall be measured as true RMS voltages. The following functions shall be monitored:

a. Output voltage, phase-to-phase and phase-to-ground (all three phases).

a. Output current, all three phases.

b. Output frequency.

c. Bypass voltage, phase-to-phase and phase-to-ground (all three phases).

d.Output kilowatts.

e.Output kilovars.

f.Output kVA.

g.Output kilowatt-hours, with demand attachment.

h.Maintenance bypass voltage, phase-to-phase and phase-to-ground (all three phases).

2.8.3.2 System Controls

The system cabinet shall include the following controls:

a. Lamp test/reset.

b. Alarm test/reset.

c. Voltage adjustment potentiometer.

d. Emergency off pushbutton with protective cover.

e. UPS/bypass transfer selector switch.

f. Static switch enable/disable selector switch.

g. Control power off switch.

2.8.3.3 System Alarm Indicators

The system control panel shall contain indicators for the following additional alarm items. Any one of these alarm conditions shall also activate the audible alarm. Each new alarm shall register without affecting previous alarms.

a. Module summary alarm, one for each UPS module.

b. UPS on battery.

c. Low battery voltage.

d. Critical load on bypass.

e. Static switch disable.

f. Output overvoltage.

g. Output undervoltage.

h. Output overfrequency.

i. Output underfrequency.

j. Overload.

k. Bypass source overvoltage.

l. Bypass source undervoltage.

m. Bypass source overfrequency.

n. Bypass source underfrequency.

o. Bypass source to inverter out of synchronization.

p. Equipment overtemperature.

q. Control power failure.

2.8.3.4 System Mimic Panel

The system control panel shall contain a mimic panel in the format of a single-line diagram, with status indicators for the following items:

Module on-line, one per UPS module.

b. UPS output protective device status, one for closed (red), one for open (green), and one for withdrawn (amber).

c. Static bypass protective device status, one for closed (red), one for open (green), and one for withdrawn (amber).

d. Static switch status, one for connected (red), and one for disconnected (green).

2.8.3.5 Emergency Off

Pressing the emergency off button shall cause the module input, output, and battery circuit breakers to open, completely isolating the UPS system from sources of power. The critical load shall be transferred to the bypass source when this occurs. The EPO button shall have a protective clear cover configured to prevent accidental or unintended activation.

2.9 SELF-DIAGNOSTIC CIRCUITS

The control logic shall include status indicators for trouble-shooting the control circuits. These indicators shall be mounted on the circuit card edge or face such that they will be visible without repositioning the card, and shall be labeled with the function name.

2.10 REMOTE MONITORING

2.10.1 Audible Alarm

Any single indicator shall also turn on the audible alarm. An audible alarm test/reset button and lamp test/reset button shall be included. This reset button shall not affect nor reset the alarm on the module or on the system cabinet.

2.11 COMMUNICATIONS AND DATA ACQUISITION PORT

a. An RS 485 Mobus Protocol communications and data acquisition port shall be provided. This port shall allow the system parameters, status, alarm indication and control panel functions specified to be remotely monitored.

b. Each UPS module shall be equipped with multi-function power monitoring with test switches which shall be used to monitor the UPS output to the UPS load distribution. The UPS load distribution shall be equipped with a power monitor. Communication to the electrical monitoring system shall be implemented via a module serial communication media. The power monitor should include the following quantities:

1) kW
2) kVA
3) kVAR
4) kVARH
5) +kW Demand
6) Amperes Demand
7) Power Factor
8) A Phase Current
9) B Phase Current

10) C Phase Current
11) Neutral Current
12) A-B Voltage
13) B-C Voltage
14) A-C Voltage

c. The Power Monitors shall be equipped with a minimum of four programmable discrete inputs for integrating the UPS discrete alarm points. The Power Monitors shall be provided with dual communication ports. The power monitor shall have a DNP3.0 Level 2 or Modbus RTU protocol serial interface. One port will be used for these protocols for communication to a SCADA system RTU and the second will communicate to the SCADA system engineering workstation using Power Measurement Limited Co. "ION" protocol. External power to the Power Monitors shall be provided by the external Uninterruptible Power Supply (UPS) service.

2.11.1 Indication of UPS Status and Alarms

a. A dry "a" contact from the UPS system to monitor "on-line" status shall be connected to one of the multifunction power monitor programmable input points.

b. A dry "a" contact from the UPS system to monitor "load on batteries" alarm/status shall be connected to one of the multifunction power monitor programmable input points.

c. A dry "a" contact from the UPS system to monitor "load on bypass" alarm/status shall be connected to one of the multifunction power monitor programmable input points.

d. A dry "a" contact from the UPS system to monitor "UPS summary alarm" alarm/status shall be connected to one of the multifunction power monitor programmable input points.

e. By installing a multifunction power monitor at each UPS, a comprehensive list of parameters can be monitored without having to interface with the individual UPS internal monitoring systems other than to obtain the four contact inputs.

2.11.2 UPS Room Environmental Conditions

Analog ambient temperature transmitters shall be installed to monitor the temperature in the UPS rooms and shall be connected to the SCADA system RTU analog inputs. The temperature transmitter shall be industrial/commercial service devices with 4-20 mA output externally powered analog signals.

2.11.3 Battery Monitoring Systems

Battery monitoring systems shall be connected to the SCADA system.

2.12 TEMPERATURE CONTROL
2.12.1 General

Cabinet and enclosure ventilation shall be adequate to ensure that components are operated within their ratings. Forced-air cooled rectifier, inverter, and control unit will be acceptable. The cooling fans shall

continue operation if UPS input power is lost. Redundancy shall be provided so that failure of one fan or associated circuit breaker will not cause an overheat condition. Cooling air shall enter the lower front of the cabinets and exhaust at the top. Blower power failure shall be indicated as a visual and audible alarm on the control panel. Air inlets shall have filters that can be replaced without opening the cabinet doors.

2.12.2 Blower Power Source

Blower power source shall be internally derived from the input and output sides of UPS module, with automatic transfer arrangement.

2.12.3 Temperature Sensors

Temperature sensors shall be provided to monitor the air temperature. Separate sensors shall monitor the temperature of rectifier and inverter heat sinks. Separate sensors shall also monitor the transformer temperature. Critical equipment overtemperature indication shall start a timer that shall shut down the UPS system if the temperature does not return below the setpoint level in 30 minutes or as required to prevent critical component failure.

2.13 BATTERY SYSTEM

2.13.1 General

A wet cell storage battery system with sufficient ampere-hour rating to maintain UPS output at full capacity for the specified duration shall be provided for each UPS module. The battery shall be of heavy-duty, industrial design suitable for UPS service. The cells shall be provided with flame arrestor vents, intercell connectors and cables, cell-lifting straps, cell-numbering sets, and terminal grease. Intercell connectors shall be sized to maintain terminal voltage within voltage window limits when supplying full load under power failure conditions. Cell and connector hardware shall be stainless steel of a type capable of resisting corrosion from the electrolyte used.

2.13.1.1 OPS Building

Provide a battery disconnect circuit breaker located in the battery room to allow disconnection of the battery from the rectifier and charger for servicing and checking the battery. Where multiple parallel batteries are provided to meet the capacity requirements. Provide three pole circuit breaker when in order to separate the battery into two strings in order to allow for battery maintenance and continued operation of the UPS system. Size battery for discharge at the full rated kW capacity of the UPS, based upon the back-up time and cell voltage limits listed earlier under "DC System", over the entire 20-year period. Battery sizing shall be based upon four full discharges per year over the entire 20-year period. Size battery string to allow up to 4 cells to be removed from the string while still allowing full rated battery backup under full load conditions without exceeding cell voltage limits. Size battery to ensure that 100 percent rated UPS capacity will be delivered up to the end of the 20th year of battery life. Cells shall be shipped in a state of charge that will allow at least 100 percent battery capacity no more than 72 hours of on-site charging. ambient temperature for the battery area will be 77 degrees F.

2.13.1.2 Antenna Farm
Provide VRLA cell battery for the antenna Farm UPS modules.

2.13.2 Battery Ratings

a. Type: lead calcium.

b. Specific gravity when fully charged: 1.25.

c. End voltage 1.67 volts per cell.

d. Float voltage: 2.17 to 2.26 volts per cell.

e. Equalizing voltage: 2.2 to 2.45 volts per cell.

f. Warranty: 20 year.

g. Provide a 20-year pro-rated warranty for all of the battery cells. Pro-rating step for a given year shall be held throughout the entire year and shall be based upon the cost of new cells in the year of purchase. Pro-rating shall be as follows:

1) Cell failure at any time during the first year shall be covered at 100 percent of replacement cost.

2) Cell failure at any time during the second year shall be covered at 95 percent of replacement cost; etc. This shall be continued in a straight line fashion until year twenty when cell failure at any time during the 20th year shall be covered at 5 percent of replacement cost.

2.13.3 Battery Construction

The battery shall be of wet cell, calcium flat plate and shall be supplied complete with thermometer and hydrometer holder.

2.13.4 Battery Cabinet

The battery pack assemblies for the antenna farm UPS modules shall be furnished in a battery cabinet matching the UPS cabinet. The battery cabinet shall be designed to allow for checking the torque on the connections in the battery system and to provide adequate access for annual housekeeping chores. External wiring interface shall be through the bottom or top of the assembly. A smoke and high temperature alarm shall annunciate detection of either smoke or high temperature within the battery cabinet.

2.13.5 Cell-Terminal Covers

Acid-resistant transparent cell-terminal covers not exceeding 6 feet in length and with vent holes drilled on top where needed shall be provided.

2.13.6 Battery Disconnect

Each battery pack assembly shall have a non-Automatic dc rated circuit breaker provided in a NEMA 1 enclosure, finished with acid-resistant paint and located in line with the assembly. Switch shall be complete with line side and load side bus bars for connection to battery cells. The circuit

breaker shall be rated 600 V dc, ampere rating as required by system, 2-pole with interrupting rating as required by system capacity, and shall have an external operator that is lockable in the "off" position.

2.13.7 Seismic Requirements

The battery support system shall conform to Sections 16070 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

2.13.8 Battery Monitor

a. A battery monitor shall be provided for each battery pack assembly. At a minimum, this device shall monitor the following parameters:

1. Total system voltage.

2. Ambient room temperature

3. Total battery discharge cycles with a duration of 30 seconds or less.

b. The monitor shall also record the total accumulated discharge minutes and accumulated battery system discharge kW hours and shall have a BS485 ModBus interface.

c. Each cell shall be labeled with number in string and date installed.

2.14 FACTORY TESTING

The UPS system shall be factory tested to meet the requirements specified using a test battery (not the battery to be supplied with the system). UPS module shall be factory load tested as an independent assembly with 3-phase ac input power and with battery power for a minimum of 8 hours, with meter readings taken every 30 minutes. Load shall be balanced at rated kVA and rated power factor. Factory tests for the UPS module shall be run under full load, and be witnessed by the Contracting Officer. Should a malfunction occur, the problem shall be corrected and the test shall be repeated. As a minimum, the factory tests shall include the parameters described in paragraphs ac Input, ac Output, Transient Response and Efficiency. The tests shall encompass all aspects of operation, such as module failure, static bypass operation, battery failure, input power failure and overload ratings. The Government shall be notified in writing at least 2 weeks before testing. Factory-test time shall not be used for system debugging and/or checkout. Such work shall be done prior to notifying the Contracting Officer that the system is ready for testing. Factory tests shall be performed during normal business hours. The system shall be interconnected and tested for an additional 8 hours to ensure proper wiring and performance.

2.14.1 Transient Tests

Transient tests shall be conducted using high-speed oscillograph type recorders to demonstrate the operation of the components to the satisfaction of the Government. These tests shall include 50 percent to 100 percent load changes, manual transfer, manual retransfer, low dc bus initiated transfer and low ac output bus transfer. A recording instrument equipped with an event marker shall be used.

2.14.2 Efficiency Tests

Testing for efficiency shall be performed at zero output up to 100 percent of stated kVA output in 25 percent steps, 0.9 power factor, with battery fully charged and floating on the dc bus, with nominal input voltage, and with modules connected to the system to represent actual operating conditions.

2.15 INSPECTION

Inspection before shipment is required. The manufacturer shall notify the Contracting Officer at least 2 weeks before shipping date so that an inspection can be made.

PART 3 EXECUTION

3.1 INSTALLATION

The UPS system shall be set in place, wired and connected in accordance with the approved shop drawings and manufacturer's instructions.

3.1.1 Control Cable

UPS control wiring shall be stranded type and must be installed in individual separate conduits. Tag control wires with numeric identification tags corresponding to the terminal strip location to where the wires are connected. In addition to manufacturer's requirements, provide four additional spare conductors between UPS module and remote alarm panel, if used, in same conduit. When routing control cables inside UPS module, maintain a minimum 6 inches separation from power cables.

3.1.2 Grounding Conductor

Provide an insulated equipment grounding conductor in feeder and branch circuits. Conductor shall be separate from the electrical system neutral conductor. Ground battery racks and battery breaker cabinets with a separate equipment grounding conductor to the UPS cabinet.

3.1.3 UPS Output Conductors

Isolate the UPS output conductors from the UPS cabinet to the critical load panels and from other conductors by installing in separate conduit or separate cable bus as indicated. Isolation shall prevent inductive coupling from other conductors.

3.1.4 DC Power Conductors

When installed in conduits, place DC power conductors from the UPS cabinet to the battery circuit breaker such that each conduit contains an equal number of positive and negative conductors, for example, two positive and two negative conductors in each conduit.

3.1.5 Emergency Control Contacts

Provide normally open contacts for each UPS system to signal when power is supplied to the UPS from emergency engine generators. Installation shall conform to manufacturer's installation drawings.

3.1.6 Cable Lugs
Provide appropriate insulated compression type lugs on all AC and DC power connections to the UPS system and battery as required. Aluminum or bare copper cable lugs are not suitable.

3.1.7 Seismic Protection

Provide equipment anchor to protect against seismic shock in accordance with applicable local regulations. Seismic mounting and bracing as required shall be in accordance with Section 16070 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

3.1.8 Conduit and Conductor Entries

Provide conduits or cable bus conductor entries, as applicable, using the available conduit areas shown on manufacturer's installation drawings. Entries shall not be made through the front, side or rear panels of the UPS, Maintenance Bypass Cabinets or System Control Cabinet.

3.1.9 Battery Rack Assembly

Battery racks are shipped dismantled in separate rail, frame, and brace packages. Ensure that necessary assembly hardware is included in the frame packages. Installation of battery racks shall conform to the manufacturer's instructions. Seismic mounting and bracing as required shall be in accordance with Section 16070 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

3.1.10 Battery Installation

Installation of battery shall conform to the manufacturer's instructions.

3.1.10.1 Positioning Cells

Use lifting belt and spreader when lifting the cells with mechanical equipment such as a crane or hoist. Install cells on racks in accordance with manufacturer's instructions. Ensure each hydrometer tube is located on aisle side of each cell.

3.1.10.2 Connecting Cells

Cleaning contact surfaces, application of no-oxide grease, and connection of cells shall be in accordance with the manufacturer's instructions. No-oxide grease is applied only on connection surfaces.

3.1.10.3 Inter-Rack and Inter-Tier Cables

Provide flexible, welding type cable for all inter-rack and inter-tier connections. Number and size shall be as rquired by maximum discharge current and cable ampacity. Battery cables shall have a long bending radius to avoid excessive stress at the point of termination.

3.2 UPS TECHNICAL REPRESENTATIVE

Contractor shall notify Contracting Officer in writing at least 45 calendar days prior to completion of the UPS system installation. At this time the Contracting Officer, via NFESC ECDet, Code 65, will schedule the UPS manufacturer's technical representative to inspect the completed installation. The UPS technical representative will provide 15 days of

service including five days of instruction for activity personnel. The following items shall be completely installed by the Contractor and be operational prior to the arrival of the UPS representative for inspection, unit start-up and testing:

a. Ventilation equipment in the UPS and battery rooms.

b. Battery racks and cells. Cells shall not be filled with electrolyte until directed by the Contracting Officer. This is not applicable for maintenance free battery.

c. Battery connections including cell-to-cell, tier-to-tier, and rack-to-rack connections, with correct polarity;

d. DC power and control connections between UPS and battery circuit breaker, with correct polarity;

e. DC power connection between battery circuit breaker and battery, with correct polarity;

f. Clockwise phase rotation of AC power connections;

g. AC power to rectifier input bus;

h. AC power to UPS bypass input bus;

i. AC power to UPS maintenance bypass circuit breaker;

j. AC power from UPS output to UPS maintenance bypass output circuit breaker;

j. Remote monitors and control wiring;

k. UPS system and battery system properly grounded;

l. Emergency shower and eye wash;

n. Control connections between UPS and emergency engine generator signal contacts;

o. Control connections between UPS modules UPS maintenance bypass cabinet and system control cabinet; and

p. Clean and vacuum UPS and battery room floors, battery cells, and UPS equipment, both inside and outside.

3.2.1 Contractor Duties

Prior to the arrival of the UPS technical representative, Contractor shall furnish the following for testing:

a. Load bank with temporary jumper cables.

b. Calibrated digital voltmeter with 0.01 volt resolution.

3.2.1.1 Data Center Equipmet and Conduit Color Code marking

All equipment, compoents, and conduits associated with a UPS distribution system shall be visiably markd with the following color code.

3.2.1.1.1 DATA Center Power Color Code

UPS System	Channel	Background	Accent Stripe	Lettering	
A	1	Yellow	Blue	Blue or Black	A 1
	2	Blue	Yellow	Yellow or White	A 2
B	1	Orange	Violet	Violet or Black	B 1
	2	Violet	Orange	Orange or White	B 2
C	1	Red	Green	Green or White	C 1
	2	Green	Red	Red or White	C 2

3.2.2 Installation Inspection

The UPS technical representative and the Contracting Officer, in the presence of the Contractor, will inspect the completed installation. The Contractor shall correct construction or installation deficiencies as directed.

3.3 BATTERY FILING AND CHARGING

a. At all times while in the battery room, personnel shall wear the proper safety items as deemed necessary by their task. This shall include, but not be limited to, chemical and splash-resistant goggles, face shield, impermeable apron, and acid resistant boots and gloves. Contractor shall provide one extra set of safety equipment for Contracting Officer.

3.4 FIELD QUALITY CONTROL

Contractor shall be on-site during UPS system testing. Provide equipment, test instruments, power, load bank, materials and labor required for tests. Contracting Officer will witness all tests and the tests shall be subject to his approval. Defects resulting from improper handling or installation shall be corrected by the Contractor and retested at no additional cost to the Government. Defects resulting from non-Contractor furnished equipment failure shall be repaired by equipment manufacturer. Contracting Officer will make final decisions as to whether a failure was due to improper installation or defective non-Contractor furnished equipment.

3.5 FIELD SUPERVISION, STARTUP AND TESTING

The services of a manufacturer's representative who is experienced in the installation, adjustment, and operation of the equipment specified shall be provided. The representative shall supervise the installation, adjustment and testing of the equipment. The representative shall check the wiring between equipment, start up the system, and field test the functions, interlocks and protective devices to ensure that the total system is functioning according to the intent of the design. The field tests shall be performed under the supervision of a factory-trained representative of the equipment manufacturer and witnessed by the Government. The Government shall be given 2 weeks written advance notice of the date and time when testing will be conducted.

3.5.1 Field Tests

As a minimum, the startup and field test procedures shall include the following:

a. Ensure that shipping members have been removed.

b. Check for damage (dents, scratches, frame misalignment, damage to panel devices, etc).

c. Ensure that interiors are free of foreign materials, tools and dirt.

d. Attach a phase rotation meter to the UPS input, output and bypass buses, and observe proper phase sequences.

e. Torque test bus connections at shipping splits. Also torque test battery connections.

e. Check each electrical bus for proper phasing and identification.

f. Check and test selector switches and meters for proper operation.

g. Check doors for proper alignment and operation.

i. Check and test each protective device for proper mechanical and electrical operation.

k. Check protective device overcurrent trip settings.

l. Check and test indicating lights for proper operation and color.

m. Perform onsite field test procedures.

n. Demonstrate to the Government that the specified functions and interlocks have been implemented.

o.Provide IEEE Std 450 battery installation certification.

p. Check key interlock key numbers, if used, to ensure agreement with interlocking scheme.

3.5.2 Load Test

The installed system shall be load tested for a continuous 24 hour period by means of resistive load banks. The system shall be continuously tested at 1/2 load for 8 hours, 3/4 load for 8 hours and full load for 8 hours. The equipment manufacturer shall provide resistive load banks of total kW load of equipment to facilitate startup under load conditions, and to conduct load tests described above. Instrument readings shall be recorded every half hour for the following:

a. Input voltage (all three phases, for each module).

b. Input current (all three phases, for each module).

c. Input frequency.

d. Battery voltage for each module.

e. Output voltage (all three phases, for each module).

f. Output current (all three phases, for each module).

g. Output kilowatts for each module.

h. Output frequency.

i. Output voltage (all three phases - system output).

j. Output current (all three phases - system output).

k. Output kilowatts (system output).

3.5.3 Full Load Burn In Test

The installed system shall undergo an additional full load burn-in period of 24 continuous hours. If a failure occurs during the burn-in period, the tests shall be repeated. Instrument readings shall be recorded every half hour as above. During the burn-in period, the following tests shall be performed:

a. With the UPS carrying maximum continuous design load and supplied from the normal source, switch 100 percent load on and off a minimum of five times within the burn-in period.

b. With the UPS carrying maximum continuous design load and supplied from the emergency source, repeat the switching operations described in step a. Also, verify that the UPS module rectifier charger unit(s) go into the second-step current limit mode.

c. With the UPS carrying maximum continuous design load and operating on battery power, repeat the switching operations described in step a above.

d. Continue operation on battery power for 1 minute, then restore normal power.

The Contractor shall furnish a high-speed dual trace oscillograph to monitor ten or more cycles of the above tests at the ON and OFF transitions and two typical steady-state periods, one shortly after the load is energized (at 30 to 60 seconds) and one after operation has stabilized (at 8 to 10 minutes). Four copies of the traces shall be delivered to the Contracting Officer.

3.5.4 Battery Discharge Test

With the battery fully charged, the system shall undergo a complete battery discharge test to full depletion and a recharge to nominal conditions. Instrument readings shall be recorded every minute during discharge for the following:

a. Battery voltage for each module.

b. Cell voltage for each cell as provided by the battery monitoring system.

c.Battery current for each module.

d.Output voltage (all three phases) for each module.

e.Output current (all three phases) for each module.

f.Output kilowatts for each module.

g.Output voltage (all three phases - system output).

h.Output current (all three phases - system output).

i.Output kilowatts (system output).

j.Output frequency.

3.6 POSTING FRAMED DATA AND INSTRUCTIONS

Framed data and instructions containing wiring and control diagrams under glass or in laminated plastic shall be posted where directed. Condensed operating instructions, prepared in typed form, shall be framed as specified above and posted beside the diagrams. The framed instructions shall be posted before acceptance testing of the system.

3.7 FIELD TRAINING

A field training course shall be provided for designated operating and maintenance staff members. Training shall be provided for a total period of 12 hours of normal working time and shall start after the system is functionally complete but prior to final acceptance test. Field training shall cover the items contained in the operating and maintenance manuals. The 12 hours shall be divided into two sessions of 6 hours each. Each session shall be conducted on a different day. Field training shall be videotaped and the tape shall be left with the Contracting Officer.

-- End of Section --

SECTION 16272
THREE-PHASE PAD-MOUNTED TRANSFORMERS
04/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D 1535 (2001) Specifying Color by the Munsell System

ASTM D 877 (2002e1) Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes

ASTM D 92 (2002b) Flash and Fire Points by Cleveland Open Cup Tester

ASTM D 97 (2004) Pour Point of Petroleum Products

FM GLOBAL (FM)

FM P7825 (2005) Approval Guide

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2 (2005) National Electrical Safety Code

IEEE C57.12.00 (2000) General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers

IEEE C57.12.28 (2005) Pad-Mounted Equipment - Enclosure Integrity

IEEE C57.12.34 (2004) Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers, 2500 kVA and Smaller—High-Voltage: 34 500 GrdY/19 920 Volts and Below; Low Voltage: 480 Volts and Below

IEEE C57.12.80 (2002) Terminology for Power and Distribution Transformers

IEEE C57.12.90 (1999) Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers

IEEE C57.98 (1994) Guide for Transformer Impulse Tests

IEEE C62.11 (1999) Metal-Oxide Surge Arresters for

	Alternating Current Power Circuits (>1KV)
IEEE Std 100	(2000) The Authoritave Dictionary of IEEE Standards Terms
IEEE Std 386	(1995) Separable Insulated Connector Systems for Power Distribution Systems Above 600V

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2003) Acceptance Testing Specifications

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA C37.47	(1981) Distribution Fuse Disconnecting Switches, Fuse Supports, and Current-Limiting Fuses**

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2005) National Electrical Code

ORGANIZATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)

OECD Test 203	(1992) Fish Acute Toxicity Test

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 600/4-90/027F	(1993) Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms
EPA 712-C-98-075	(1996) Fate, Transport and Transformation Test Guidelines - OPPTS 835.3100- "Aerobic Aquatic Biodegradation"

UNDERWRITERS LABORATORIES (UL)

UL 467	(2004) Grounding and Bonding Equipment

1.2 RELATED REQUIREMENTS

Section 16081 APPARATUS INSPECTION AND TESTING applies to this section, with the additions and modifications specified herein.

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE Std 100.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only

. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

a. Routine and other tests (in PART 2, see paragraph entitled "Routine and Other Tests"), shall be conducted by the manufacturer and may be witnessed by the government (in Part 2, see paragraph entitled "Source Quality Control"). Provide transformer test schedule required by submittal item "SD-11 Closeout Submittals". Provide certified copies of the tests.

b. Provide acceptance test reports required by submittal item "SD-06 Test Reports".

c. Provide operation and maintenance manuals required by submittal item "SD-10 Operation and Maintenance Data".

SD-02 Shop Drawings

Pad-mounted transformer drawings; G,

SD-03 Product Data

Pad-mounted transformers; G,

Submittal shall include manufacturer's information for each component, device, and accessory provided with the transformer.

SD-06 Test Reports

Acceptance checks and tests; G,

SD-07 Certificates

Transformer losses; G,

Submit certification from the manufacturer indicating conformance with the paragraph entitled "Specified Transformer Losses."

SD-09 Manufacturer's Field Reports

Pad-mounted transformer design tests; G,

Pad-mounted transformer routine and other tests; G,

SD-10 Operation and Maintenance Data

Transformer(s), Data Package 5; G,

Submit operation and maintenance data in accordance with Section 01781 OPERATION AND MAINTENANCE DATA and as specified herein.
SD-11 Closeout Submittals

Transformer test schedule; G,

Submit report of test results as specified by paragraph entitled "Field Quality Control."

1.5 QUALITY ASSURANCE

1.5.1 Pad-Mounted Transformer Drawings

Drawings shall indicate, but not be limited to the following:

a. An outline drawing, with front, top, and side views.

b. ANSI nameplate data.

c. Elementary diagrams and wiring diagrams with terminals identified of watthour meter and current transformers.

d.One-line diagram, including switch(es), and fuses.

e. Manufacturer's published time-current curves (on full size logarithmic paper) of the transformer high side fuses.

1.5.2 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.5.3 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section. All electrical products shall be installed according to the manufactures instructions.

1.5.3.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.3.2 Material and Equipment Manufacturing

Date Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.6 MAINTENANCE

1.6.1 Additions to Operation and Maintenance Data

In addition to requirements of Data Package 5, include the following on the actual transformer(s) provided:

a. An instruction manual with pertinent items and information highlighted

b. An outline drawing, front, top, and side views

c. Prices for spare parts and supply list

d. Routine and field acceptance test reports

e. Fuse curves for primary fuses

f. Actual nameplate diagram

g. Date of purchase

1.7 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

Products and materials not considered to be pad-mounted transformers and related accessories are specified in Section 16302 UNDERGROUND TRANSMISSION AND DISTRIBUTION or Section 16402 INTERIOR DISTRIBUTION SYSTEM.

2.2 THREE-PHASE PAD-MOUNTED TRANSFORMERS

IEEE C57.12.34, IEEE C57.12.28 and as specified herein.

2.2.1 Compartments

The high- and low-voltage compartments shall be separated by steel isolating barriers extending the full height and depth of the compartments. Compartment doors: hinged lift-off type with stop in open position and three-point latching.

2.2.1.1 High Voltage, Dead-Front

High-voltage compartment shall contain the incoming line, insulated high-voltage load-break connectors, bushing well inserts, load-break switch handle(s), access to oil-immersed fuses, dead-front surge arresters, tap changer handle, connector parking stands, and ground pad.

a. Insulated high-voltage load-break connectors: IEEE Std 386, rated 15 kV, 95 kV BIL. Current rating: 200 amperes rms continuous. Short time rating: 10,000 amperes rms symmetrical for a time duration of 0.17 seconds. Connector shall have a steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material.

b. Bushing well inserts: IEEE Std 386, 200 amperes, 15 kV Class. Provide a bushing well insert for each bushing well unless indicated otherwise.

c. Load-break switch

Loop feed sectionalizer switches: Provide a four position, ("T") oil-immersed type switch to permit closed transition loop feed and sectionalizing. Each switch shall be rated at 15 kV, 95 kV BIL, with a continuous current rating and load-break rating of 200 amperes, and a make-and-latch rating of 10,000 rms amperes symmetrical. Locate the switch handles in the high-voltage compartment. Operation of switches shall be as follows:

ARRANGE-MENT NO.	DESCRIPTION OF SWITCH ARRANGEMENT	SWITCH POSITION LINE A SW. OPEN	LINE A SW. CLOSE	LINE B SW OPEN	LINE B SW CLOSE	XFMR. SW OPEN	XFMR. SW CLOSE
1	Transformer connected to Line A only		X	X			X
2	Transformer connected to Line B only	X			X		X
3	Transformer open and loop closed		X		X	X	
4	Transformer open and loop open	X		X		X	

d. Provide bayonet type, oil-immersed, expulsion fuses. Bayonet fuse links shall sense both high currents and high oil temperature in order to provide thermal protection to the transformer. Coordinate transformer protection with expulsion fuse clearing low-current faults and current-limiting fuse clearing high-current faults beyond the interrupting rating of the expulsion fuse. In order to eliminate or minimize oil spills, the bayonet fuse assembly shall include an oil retention valve inside the housing which closes when the fuse holder is removed and an external drip shield. Warning shall be conspicuously displayed within the high-voltage compartment cautioning against removing or inserting fuses unless the load-break switch is in the open position and the tank pressure has been released.
Bayonet fuse assembly: 150 kV BIL.

Oil-immersed current-limiting fuses: NEMA C37.47; 50,000 rms amperes symmetrical interrupting rating at the system voltage specified. Connect current-limiting fuses ahead of the radial-feed load-break switch.

f. Surge arresters: IEEE C62.11, rated as indicated, fully shielded, dead-front, metal-oxide-varistor, elbow type with resistance-graded gap, suitable for plugging into inserts. Provide three arresters for radial feed circuits. Provide six arresters for loop feed circuits.

g. Parking stands: Provide a parking stand near each bushing well. Provide insulated standoff bushings for parking of energized load-break connectors on parking stands.

2.2.1.2 Low Voltage

Low-voltage compartment shall contain low-voltage bushings with NEMA spade terminals, accessories, metering, stainless steel or laser-etched anodized aluminum diagrammatic transformer nameplate, and ground pad.

a. Accessories shall include drain valve with sampler device, fill plug, pressure relief device, liquid level gage, pressure-vacuum gage, and dial type thermometer with maximum temperature indicator.

2.2.2 Transformer

a. Less-flammable liquid-insulated, two winding, 60 hertz, 65 degrees C rise above a 30 degrees C average ambient, self-cooled type.

b. Transformer shall be rated as indicated on the drawings, 95 kV BIL.

d. Transformer voltage ratings shall be as indicated on the drawings.

d. Tap changer shall be externally operated, manual type for changing tap setting when the transformer is de-energized. Provide four 2.5 percent full capacity taps, two above and two below rated primary voltage. Tap changers shall clearly indicate which tap setting is in use.

e. Minimum tested impedance shall not be less than 5 percent at 85 degrees C.

e. Audible sound levels shall comply with the following:

kVA	DECIBELS (MAX)
75	51
112.5	55
150	55
225	55
300	55
500	56
750	57
1000	58
1500	60

g. Transformer shall include lifting lugs and provisions for jacking under base. The transformer base construction shall be suitable for using rollers or skidding in any direction. Provide transformer top with an access handhole. Transformer shall have its kVA rating conspicuously displayed on its enclosure. The transformer shall have an insulated low-voltage neutral bushing with NEMA spade terminal, and with removable ground strap.

2.2.2.1 Specified Transformer Losses

No-load losses (NLL) at 20 degrees C and load losses (LL) at 85 degrees C

shall be as indicated in UFGS transformer table PM-2. The values for the specified losses shall be used for comparison with the losses determined during the routine tests. If the routine test values for no-load losses exceed the specified no-load losses by more than 10 percent, or the total losses exceed the specified total losses (sum of no-load and load losses) by more than 6 percent, the transformer is unacceptable.

2.2.3 Insulating Liquid

a. Less-flammable transformer liquids: NFPA 70 and FM P7825 for less-flammable liquids having a fire point not less than 300 degrees C tested per ASTM D 92 and a dielectric strength not less than 33 kV tested per ASTM D 877. Provide identification of transformer as "non-PCB" and "manufacturer's name and type of fluid" on the nameplate. The fluid shall be a biodegradable electrical insulating and cooling liquid classified by UL and approved by FM as "less flammable" fluids. The fluid shall meet the following fluid properties:

1. Pour point: ASTM D 97, less than -15 degree C

2. Aquatic biodegradation: EPA 712-C-98-075, 100%

3. Trout toxicity: OECD Test 203, zero mortality of EPA 600/4-90/027F, Pass

2.2.3.1 Liquid-Filled Transformer Nameplates

Distribution transformers shall be provided with nameplate information in accordance with IEEE C57.12.00 and as modified or supplemented by this section.

2.2.4 Corrosion Protection

Paint entire transformer assembly Munsell 7GY3.29/1.5 green. The Munsell color notation is specified in ASTM D 1535.

2.3 WARNING SIGNS

Provide warning signs for the enclosures of pad-mounted transformers having a nominal rating exceeding 600 volts.

a. When the enclosure integrity of such equipment is specified to be in accordance with IEEE C57.12.28, such as for pad-mounted transformers, provide self-adhesive warning signs on the outside of the high voltage compartment door(s). Sign shall be a decal and shall have nominal dimensions of 7 by 10 inches with the legend "DANGER HIGH VOLTAGE" printed in two lines of nominal 2 inch high letters. The word "DANGER" shall be in white letters on a red background and the words "HIGH VOLTAGE" shall be in black letters on a white background. Decal shall be Panduit No. PPSO710D72 or approved equal.

b. When such equipment is guarded by a fence, mount signs on the fence. Provide Aluminum with baked enamal signs having nominal dimensions of 14 by 10 inches with the legend "DANGER HIGH VOLTAGE KEEP OUT" printed in three lines of nominal 3 inch high white letters on a red and black field.

2.4 GROUNDING AND BONDING

UL 467. Provide grounding and bonding as specified in Section 16302 UNDERGROUND TRANSMISSION AND DISTRIBUTION.

2.5 PADLOCKS

Padlocks shall be provided for pad-mounted equipment and for each fence gate. Padlocks shall be keyed as directed by the Contracting Officer.

2.6 CAST-IN-PLACE CONCRETE

Concrete associated with electrical work for other than encasement of underground ducts shall be 4000 psi minimum 28-day compressive strength unless specified otherwise. All concrete shall conform to the requirements of Section 03300 CAST-IN-PLACE CONCRETE.

2.7 SOURCE QUALITY CONTROL

2.7.1 Transformer Test Schedule

The Government reserves the right to witness tests. Provide transformer test schedule for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 30 calendar days before scheduled test date. Notify Contracting Officer 15 calendar days in advance of changes to scheduled date.

a. Test Instrument Calibration

1. The manufacturer shall have a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

2. The accuracy shall be directly traceable to the National Institute of Standards and Technology.

3. Instrument calibration frequency schedule shall not exceed 12 months for both test floor instruments and leased specialty equipment.

4.Dated calibration labels shall be visible on all test equipment.

5. Calibrating standard shall be of higher accuracy than that of the instrument tested.

6. Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:

(a) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

(b) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

2.7.2 Design Tests

IEEE C57.12.00, and IEEE C57.12.90. Section 5.1.2 in IEEE C57.12.80 states that "design tests are made only on representative apparatus of basically the same design." Submit design test reports (complete with test data, explanations, formulas, and results), in the same submittal package as the catalog data and drawings for each of the specified transformer(s). Design tests shall have been performed prior to the award of this contract.

a. Tests shall be certified and signed by a registered professional engineer.

b. Temperature rise: "Basically the same design" for the temperature rise test means a pad-mounted transformer with the same coil construction (such as wire wound primary and sheet wound secondary), the same kVA, the same cooling type (ONAN), the same temperature rise rating, and the same insulating liquid as the transformer specified.

c. Lightning impulse: "Basically the same design" for the lightning impulse dielectric test means a pad-mounted transformer with the same BIL, the same coil construction (such as wire wound primary and sheet wound secondary), and a tap changer, if specified. Design lightning impulse tests shall include the primary windings only of that transformer.

1. IEEE C57.12.90, paragraph 10.3 entitled "Lightning Impulse Test Procedures," and IEEE C57.98.

2.State test voltage levels.

3. Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test report.

d. Lifting and moving devices: "Basically the same design" requirement for the lifting and moving devices test means a test report confirming that the lifting device being used is capable of handling the weight of the specified transformer in accordance with IEEE C57.12.34.

e. Pressure: "Basically the same design" for the pressure test means a pad-mounted transformer with a tank volume within 30 percent of the tank volume of the transformer specified.

f. Short circuit: "Basically the same design" for the short circuit test means a pad-mounted transformer with the same kVA as the transformer specified.

2.7.3 Routine and Other Tests

IEEE C57.12.00. Routine and other tests shall be performed by the manufacturer on each of the actual transformer(s) prepared for this project to ensure that the design performance is maintained in production. Submit test reports, by serial number and receive approval before delivery of equipment to the project site. Required tests and testing sequence shall be as follows:

a. Cold resistance measurements (provide reference temperature)

b. Phase relation

c. Ratio

d. No-load losses (NLL) and excitation current

e. Load losses (LL) and impedance voltage

f. Dielectric

1. Impulse

2. Applied voltage

3. Induced voltage

g. Leak

h. Dissolved gas analysis (DGA)

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations shall conform to IEEE C2, NFPA 70, and to the requirements specified herein. Provide new equipment and materials unless indicated or specified otherwise.

3.2 GROUNDING

NFPA 70 and IEEE C2, except that grounding systems shall have a resistance to solid earth ground not exceeding 5 ohms.

3.2.1 Grounding Electrodes

Provide driven ground rods as specified in Section 16402 INTERIOR DISTRIBUTION SYSTEM. Connect ground conductors to the upper end of ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.2.2 Pad-Mounted Transformer Grounding

Provide separate copper grounding conductors and connect them to the ground loop as indicated. When work in addition to that indicated or specified is required to obtain the specified ground resistance, the provision of the contract covering "Changes" shall apply.

3.2.3 Connections

Make joints in grounding conductors and loops by exothermic weld or compression connector. Exothermic welds and compression connectors shall be installed as specified in Section 16402 INTERIOR DISTRIBUTION SYSTEM.

3.2.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.3 TRANSFORMER GROUNDING

Unless otherwise shown, provide a 1/0 bare copper-ground girdle around transformer. Girdle shall be buried one foot deep and placed 3 feet laterally from the transformer enclosure. Connect girdle to enclosure at two opposite places using 1/0 copper. Exothermically weld joints.

3.4 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect pad-mounted transformers furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.5 FIELD APPLIED PAINTING

Where field painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's instructions.

3.6 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side, but space the signs a maximum of 30 feet apart.

3.7 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

Mount transformer on concrete slab. Unless otherwise indicated, the slab shall be at least 8 inches thick, reinforced with a 6 by 6 - W2.9 by W2.9 mesh, placed uniformly 4 inches from the top of the slab. Slab shall be placed on a 6 inch thick, well-compacted gravel base. Top of concrete slab shall be approximately 4 inches above finished grade with gradual slope for drainage. Edges above grade shall have 1/2 inch chamfer. Slab shall be of adequate size to project at least 8 inches beyond the equipment.
Stub up conduits, with bushings, 2 inches into cable wells in the concrete pad. Coordinate dimensions of cable wells with transformer cable training areas.

3.7.1 Cast-In-Place Concrete

Cast-in-place concrete work shall conform to the requirements of Section 03300 CAST-IN-PLACE CONCRETE.

3.7.2 Sealing

When the installation is complete, the Contractor shall seal all conduit and other entries into the equipment enclosure with an approved sealing compound. Seals shall be of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter.

3.8 FIELD QUALITY CONTROL

3.8.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.8.1.1 Pad-Mounted Transformers

a. Visual and mechanical inspection

1. Compare equipment nameplate information with specifications and approved shop drawings.

2. Inspect physical and mechanical condition. Check for damaged or cracked insulators and leaks.

3. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

4. Verify correct liquid level in tanks.

5. Perform specific inspections and mechanical tests as recommended by manufacturer.

6.Verify correct equipment grounding.

7. Verify the presence of transformer surge arresters.

b.Electrical tests

1. Perform resistance measurements through all bolted connections with low-resistance ohmmeter.

2.Verify that the tap-changer is set at specified ratio.

3. Verify proper secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.

3.8.1.2 Grounding System

a. Visual and mechanical inspection

1. Inspect ground system for compliance with contract plans and specifications.

b. Electrical tests

1. Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground testing megger in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument shall be equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

2. Submit the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (i.e., pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

3.8.2 Follow-Up Verification

Upon completion of acceptance checks and tests, the Contractor shall show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, the Contracting Officer shall be given 5 working days advance notice of the dates and times of checking and testing.

-- End of Section --

SECTION 16302
UNDERGROUND ELECTRICAL DISTRIBUTION
02/07

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACI INTERNATIONAL (ACI)

ACI 318M	(2005) Metric Building Code Requirements for Structural Concrete and Commentary
ACI SP-66	(2004) ACI Detailing Manual

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO HB-17	(2002; Errata 2003; Errata 2005) Standard Specifications for Highway Bridges
AASHTO M 198	(2005) Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS8	(2000) Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV

ASTM INTERNATIONAL (ASTM)

ASTM B 1	(2001) Hard-Drawn Copper Wire
ASTM B 3	(2001) Soft or Annealed Copper Wire
ASTM B 496	(2004) Compact Round Concentric-Lay-Stranded Copper Conductors
ASTM B 8	(2004) Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM C 309	(2006) Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 478	(2006b) Precast Reinforced Concrete Manhole Sections
ASTM C 857	(1995; R 2001) Standard Practice for Minimum Stuctural Design Loading for Underground Precast Concrete Utility

Structures

ASTM F 512 (1995; R 2001e1) Smooth-Wall Poly (Vinyl Chloride) (PVC) Conduit and Fittings for Underground Installation

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2 (2005) National Electrical Safety Code

IEEE Std 100 (2000) The Authoritave Dictionary of IEEE Standards Terms

IEEE Std 386 (1995) Separable Insulated Connector Systems for Power Distribution Systems Above 600V

IEEE Std 404 (2000) Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V Through 500 000 V

IEEE Std 48 (1996; R 2003) Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5 kV through 765 kV

IEEE Std 81 (1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (Part 1)Normal Measurements

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS (2003) Acceptance Testing Specifications
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA C119.1 (2002) Sealed Insulated Underground Connector Systems Rated 600 Volts

NEMA RN 1 (2005) Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit

NEMA TC 3 (2004) Polyvinyl Chloride PVC Fittings for Use with Rigid PVC Conduit and Tubing

NEMA TC 6 & 8 (2003) Polyvinyl Chloride PVC Plastic Utilities Duct for Underground Installations

NEMA WC 71 (1999) Nonshielded Cables Rated 2001-5000 Volts for Use in the Distribution of Electric Energy

NEMA WC 74 (2000) 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2005; TIA 2005) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-758-A	(2004) Customer-Owned Outside Plant Telecommunications Cabling Standard

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS Bull 1751F-644	(2002) Underground Plant Construction

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-60005	(Basic; Notice 1) Frames, Covers, Gratings, Steps, Sump And Catch Basin, Manhole

UNDERWRITERS LABORATORIES (UL)

UL 1072	(2006; Rev thru Oct 2006) Medium-Voltage Power Cables
UL 1242	(2006; Rev thru Jun 2006) Electrical Intermediate Metal Conduit – Steel
UL 467	(2004) Grounding and Bonding Equipment
UL 486A-486B	(2003; Rev thru Aug 2006) Wire Connectors
UL 510	(2005; Rev thru Aug 2005) Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape
UL 514B	(2004; Rev thru Apr 2006) Conduit, Tubing and Cable Fittings
UL 6	(2004) Electrical Rigid Metal Conduit - Steel
UL 651	(2005; Rev thru Dec 2006) Schedule 40 and 80 Rigid PVC Conduit
UL 83	(2003; Rev thru Apr 2006) Thermoplastic-Insulated Wires and Cables
UL 854	(2004) Service-Entrance Cables

1.2 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE Std 100.

b. In the text of this section, the words conduit and duct are used interchangeably and have the same meaning.

c. In the text of this section, "medium voltage cable splices," and "medium voltage cable joints" are used interchangeably and have the same meaning.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Precast underground structures; G

SD-03 Product Data

Medium voltage cable; G

Medium voltage cable joints; G

Medium voltage cable terminations; G

Precast concrete structures; G

Sealing Material

Pulling and Lifting Irons

Manhole frames and covers; G

Handhole frames and covers; G

Composite/fiberglass handholes; G

Cable supports (racks, arms and insulators); G

SD-06 Test Reports

Arc-proofing test for cable fireproofing materials; G

Medium voltage cable qualification and production tests; G

Field Acceptance Checks and Tests; G

Cable Installation Plan and Procedure

Six copies of the information described below in 8-1/2 by 11 inch binders having a minimum of three rings from which material may readily be removed and replaced, including a separate section for each cable pull. Sections shall be separated by heavy plastic dividers with tabs, with all data sheets signed and dated by the person supervising the pull.

a. Site layout drawing with cable pulls numerically identified.

b. A list of equipment used, with calibration certifications. The manufacturer and quantity of lubricant used on pull.

c. The cable manufacturer and type of cable.

d. The dates of cable pulls, time of day, and ambient temperature.

e. The length of cable pull and calculated cable pulling tensions.

f. The actual cable pulling tensions encountered during pull.

SD-07 Certificates

Cable splicer/terminator; G

Cable Installer Qualifications

1.4 QUALITY ASSURANCE

1.4.1 Precast Underground Structures

Submittal required for each type used. Provide calculations and drawings for precast manholes and handholes bearing the seal of a registered professional engineer including:

a. Material description (i.e., f'c and Fy)

b. Manufacturer's printed assembly and installation instructions

c. Design calculations

d. Reinforcing shop drawingsin accordance with ACI SP-66

e. Plans and elevations showing opening and pulling-in iron locations and details

1.4.2 Certificate of Competency for Cable Splicer/Terminator

Certification of the qualification of the cable splicer/terminator shall be submitted, for approval, 30 days before splices or terminations are to be made in medium voltage (5 kV to 35 kV) cables. The certification shall include the training, and experience of the individual on the specific type and classification of cable to be provided under this contract. The certification shall indicate that the individual has had three or more years recent experience splicing and terminating medium voltage cables. The certification shall also list a minimum of three splices/terminations that have been in operation for more than one year. In addition, the individual may be required to perform a dummy or practice splice/termination in the presence of the Contracting Officer, before being approved as a qualified cable splicer. If that additional requirement is imposed, the Contractor shall provide short sections of the approved types of cables along with the approved type of splice/termination kit, and detailed manufacturer's instructions for the cable to be spliced. The Contracting Officer reserves the right to require additional proof of competency or to reject the individual and call for certification of an alternate cable splicer.

1.4.3 Cable Installer Qualifications

Provide at least one onsite person in a supervisory position with a documentable level of competency and experience to supervise all cable pulling operations. Provide a resume showing the cable installers' experience in the last three years, including a list of references complete with points of contact, addresses and telephone numbers.

1.4.4 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.4.5 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.4.5.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.4.5.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

PART 2 PRODUCTS

2.1 CONDUIT, DUCTS, AND FITTINGS

2.1.1 Markinge

All conduit marking labels shall be self-adhesive type
2.1.2 Rigid Metal Conduit UL 6.

2.1.2.1 Rigid Metallic Conduit, PVC Coated

NEMA RN 1, Type A40, except that hardness shall be nominal 85 Shore A durometer, dielectric strength shall be minimum 400 volts per mil at 60 Hz, and tensile strength shall be minimum 3500 psi.

2.1.3 Intermediate Metal Conduit UL 1242.

2.1.3.1 Intermediate Metal Conduit, PVC Coated
NEMA RN 1, Type A40, except that hardness shall be nominal 85 Shore A durometer, dielectric strength shall be minimum 400 volts per mil at 60 Hz, and tensile strength shall be minimum 3500 psi.

2.1.4 Plastic Conduit for Direct Burial UL 651, Schedule 40 or Schedule 80.

2.1.5 Plastic Duct for Concrete Encasement

NEMA TC 6 & 8 and ASTM F 512, as indicated.

2.1.6 Innerduct

Provide corrugated polyethylene (PE) or PVC innerducts with pullwire. Size as indicated.

2.1.7 Conduit Sealing Compound

Compounds for sealing ducts and conduit shall have a putty-like consistency workable with the hands at temperatures as low as 35 degrees F, shall neither slump at a temperature of 300 degrees F, nor harden materially when exposed to the air. Compounds shall adhere to clean surfaces of fiber or plastic ducts; metallic conduits or conduit coatings; concrete, masonry, or lead; any cable sheaths, jackets, covers, or insulation materials; and the common metals. Compounds shall form a seal without dissolving, noticeably changing characteristics, or removing any of the ingredients. Compounds shall have no injurious effect upon the hands of workmen or upon materials. Inflatable bladders may be used as an option.

2.1.8 Fittings

2.1.8.1 PVC Conduit Fittings

UL 514B, UL 651, NEMA TC 3.

2.1.9 Concrete Encasement

Concrete encased PVC shall be used for all medium voltage (13.8kV) feeders. Along the exterior surfaces of a building, RMC shall be used.
All underground conduit shall be concrete encased. No direct burial of any electrical feed or service shall be permitted.

2.2 LOW VOLTAGE INSULATED CONDUCTORS AND CABLES

Insulated conductors shall be rated 600 volts and conform to the requirements of NFPA 70, including listing requirements. Wires and cables manufactured more than 12 months prior to date of delivery to the site shall not be accepted. Service entrance conductors shall conform to UL 854, type USE.

2.2.1 Conductor Types
Cable and duct sizes indicated are for copper conductors and THWN unless otherwise noted. Conductors No. 10 AWG and smaller shall be solid copper.

Conductors No. 8 AWG and larger shall be stranded copper.

2.2.2 Conductor Material

Unless specified or indicated otherwise or required by NFPA 70, wires in conduit, other than service entrance, shall be 600-volt, Type THWN/THHN conforming to UL 83. Copper conductors shall be annealed copper complying with ASTM B 3 and ASTM B 8.

2.2.3 In Duct

Cables shall be single-conductor cable.

2.2.4 Cable Marking

Insulated conductors shall have the date of manufacture and other identification imprinted on the outer surface of each cable at regular intervals throughout the cable length.

Each cable shall be identified by means of a fiber, laminated plastic, or non-ferrous metal tags, or approved equal, in each manhole, handhole, junction box, and each terminal. Each tag shall contain the following information; cable type, conductor size, circuit number, circuit voltage, cable destination and phase identification. Conductors shall be color coded. Conductor identification shall be provided within each enclosure where a tap, splice, or termination is made. Conductor identification shall be by color-coded insulated conductors, plastic-coated self-sticking printed markers, colored nylon cable ties and plates, heat shrink type sleeves,or colored electrical tape. Control circuit terminations shall be properly identified. Color shall be green for grounding conductors and white for neutrals; except where neutrals of more than one system are installed in same raceway or box, other neutrals shall be white with a different colored (not green) stripe for each. Color of ungrounded conductors in different voltage systems shall be as follows

a. 208/120 volt, three-phase

(1) Phase A - black
(2) Phase B - red
(3) Phase C – blue

b. 480/277 volt, three-phase

(1) Phase A - brown
(2) Phase B - orange
(3) Phase C – yellow

2.3 LOW VOLTAGE WIRE CONNECTORS AND TERMINALS

Shall provide a uniform compression over the entire conductor contact surface. Use solderless terminal lugs on stranded conductors.

a. For use with copper conductors: UL 486A-486B.

2.4 LOW VOLTAGE SPLICES

Provide splices in conductors with a compression connector on the conductor and by insulating and waterproofing using one of the following methods which are suitable for continuous submersion in water and comply NEMA C119.1.

2.4.1 Heat Shrinkable Splice

Provide heat shrinkable splice insulation by means of a thermoplastic adhesive sealant material which shall be applied in accordance with the manufacturer's written instructions.

2.4.2 Cold Shrink Rubber Splice

Provide a cold-shrink rubber splice which consists of EPDM rubber tube which has been factory stretched onto a spiraled core which is removed during splice installation. The installation shall not require heat or flame, or any additional materials such as covering or adhesive. It shall be designed for use with inline compression type connectors, or indoor, outdoor, direct-burial or submerged locations.

2.5 MEDIUM VOLTAGE CABLE

Cable (conductor) sizes are designated by American Wire Gauge (AWG) and Thousand Circular Mils (Kcmil). Conductor and conduit sizes indicated are for copper conductors unless otherwise noted. Insulated conductors shall have the date of manufacture and other identification imprinted on the outer surface of each cable at regular intervals throughout cable length. Wires and cables manufactured more than 12 months prior to date of delivery to the site shall not be accepted. Provide single conductor type cables unless otherwise indicated.

2.5.1 Cable Configuration

Provide Type MV cable, conforming to NEMA WC 74N and UL 1072. Provide cables manufactured for use in duct applications. Cable shall be rated 105 degree C 15 kV with 133 percent insulation level.

2.5.2 Conductor Material

Provide concentric-lay-stranded, Class B compact round conductors. Provide soft drawn copper cables complying with ASTM B 3 and ASTM B 8 for regular concentric and compressed stranding or ASTM B 496 for compact stranding.

2.5.3 Insulation

Provide ethylene-propylene-rubber (EPR) insulation conforming to the requirements of NEMA WC 71 and AEIC CS8.

2.5.4 Shielding

Cables rated for 2 kV and above shall have a semiconducting conductor shield, a semiconducting insulation shield, and an overall copper tape with a minimun of 12.5% overlaping shield for each phase.

2.5.5 Neutrals

Neutral conductors of shall be copper, employing the same insulation and jacket materials as phase conductors, except that a 600-volt insulation rating is acceptable. For high impedance grounded neutral systems, the neutral conductors from the neutral point of the transformer or generator to the connection point at the impedance shall utilize copper conductors, employing the same insulation level and construction as the phase conductors.

2.5.6 Jackets

Cables shall be provided with a PVC jacket. Direct buried cables shall be rated for direct burial. Provide type UF cables with an overall jacket.

2.6 MEDIUM VOLTAGE CABLE TERMINATIONS

IEEE Std 48 Class 1; of the molded elastomer, prestretched elastomer, or heat-shrinkable elastomer. Acceptable elastomers are track-resistant silicone rubber or track-resistant ethylene propylene compounds, such as ethylene propylene rubber or ethylene propylene diene monomer. Separable insulated connectors may be used for apparatus terminations, when such apparatus is provided with suitable bushings. Terminations, where required, shall be provided with mounting brackets suitable for the intended installation and with grounding provisions for the cable shielding, metallic sheath, or armor. Terminations shall be provided in a kit, including: skirts, stress control terminator, ground clamp, connectors, lugs, and complete instructions for assembly and installation. Terminations shall be the product of one manufacturer, suitable for the type, diameter, insulation class and level, and materials of the cable terminated. Do not use separate parts of copper or copper alloy in contact with aluminum alloy parts in the construction or installation of the terminator.

2.6.1 Cold-Shrink Type

Terminator shall be a one-piece design, utilizing the manufacturer's latest technology, where high-dielectric constant (capacitive) stress control is integrated within a skirted insulator made of silicone rubber. Termination shall not require heat or flame for installation. Termination kit shall contain all necessary materials (except for the lugs). Termination shall be designed for installation in low or highly contaminated indoor and outdoor locations and shall resist ultraviolet rays and oxidative decomposition.

2.6.2 Heat Shrinkable Type

Terminator shall consist of a uniform cross section heat shrinkable polymeric construction stress relief tubing and environmentally sealed outer covering that is nontracking, resists heavy atmospheric contaminants, ultra violet rays and oxidative decomposition. Provide heat shrinkable sheds or skirts of the same material. Termination shall be designed for installation in low or highly contaminated indoor or outdoor locations.

2.6.3 Separable Insulated Connector Type

IEEE Std 386. Provide connector with steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material. Provide connectors of the loadbreak or deadbreak type as indicated, of suitable construction for the application and the type of cable connected, and that include cable shield adaptors. Provide external clamping points and test points.

a. 200 Ampere loadbreak connector ratings: Voltage: 15 kV, 95 kV BIL. Short time rating: 10,000 rms symmetrical amperes.

b. 600 Ampere deadbreak connector ratings: Voltage: 15 kV, 95 kV BIL. Short time rating: 25,000 rms symmetrical amperes.

Connectors shall have 200 ampere bushing interface as indicated.

2.7 MEDIUM VOLTAGE CABLE JOINTS

Provide joints (splices) in accordance with IEEE Std 404 suitable for the rated voltage, insulation level, insulation type, and construction of the cable. Joints shall be certified by the manufacturer for waterproof, submersible applications. Upon request, supply manufacturer's design qualification test report in accordance with IEEE Std 404. Connectors for joint shall be tin-plated electrolytic copper, having ends tapered and having center stops to equalize cable insertion.

2.7.1 Heat-Shrinkable Joint

Consists of a uniform cross-section heat-shrinkable polymeric construction with a linear stress relief system, a high dielectric strength insulating material, and an integrally bonded outer conductor layer for shielding. Replace original cable jacket with a heavy-wall heat-shrinkable sleeve with hot-melt adhesive coating.

2.7.2 Cold-Shrink Rubber-Type Joint

Joint shall be of a cold shrink design that does not require any heat source for its installation. Splice insulation and jacket shall be of a one-piece factory formed cold shrink sleeve made of black EPDM rubber. Splice shall be packaged three splices per kit, including complete installation instructions.

2.8 TAPE

2.8.1 Insulating Tape

UL 510, plastic insulating tape, capable of performing in a continuous temperature environment of 80 degrees C.

2.8.2 Buried Warning and Identification Tape

Provide detectable tape in accordance with Section 02300 EARTHWORK.

2.8.3 Fireproofing Tape

Provide tape composed of a flexible conformable unsupported intumescent elastomer. Tape shall be not less than .030 inch thick, noncorrosive to cable sheath, self-extinguishing, noncombustible, and shall not deteriorate when subjected to oil, water, gases, salt water, sewage, and fungus.

2.9 PULL ROPE

Shall be plastic or flat pull line (bull line) having a minimum tensile strength of 200 pounds.

2.10 GROUNDING AND BONDING

2.10.1 Driven Ground Rods

Provide copper-clad steel ground rods conforming to UL 467 not less than 3/4 inch in diameter by 10 feet in length. Sectional type rods may be used for rods 20 feet or longer.

2.10.2 Grounding Conductors

Stranded-bare copper conductors shall conform to ASTM B 8, Class B, soft-drawn unless otherwise indicated. Solid-bare copper conductors shall conform to ASTM B 1 for sizes No. 8 and smaller. Insulated conductors shall be of the same material as phase conductors and green color-coded, except that conductors shall be rated no more than 600 volts. Aluminum is not acceptable.

2.11 CAST-IN-PLACE CONCRETE

Provide concrete in accordance with Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE. In addition, provide concrete for encasement of underground ducts with 3000 psi minimum 28-day compressive strength. Fiber-Reinforced Concreteshall not be used. The concrete encasement for electrical ductbanks shall contain a red dye.

2.12 UNDERGROUND STRUCTURES

Provide precast concrete underground structures or standard type cast-in-place manhole types as indicated, conforming to ASTM C 857 and ASTM C 478. Top, walls, and bottom shall consist of reinforced concrete. Walls and bottom shall be of monolithic concrete construction. Locate duct entrances and windows near the corners of structures to facilitate cable racking. Covers shall fit the frames without undue play. Form steel and iron to shape and size with sharp lines and angles. Castings shall be free from warp and blow holes that may impair strength or appearance. Exposed metal shall have a smooth finish and sharp lines and arises. Provide necessary lugs, rabbets, and brackets. Set pulling-in irons and other built-in items in place before depositing concrete. Install a pulling-in iron in the wall opposite each duct line entrance. Cable racks, including rack arms and insulators, shall be adequate to accommodate the cable.

2.12.1 Cast-In-Place Concrete Structures

Concrete shall conform to Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE. Construct walls on a footing of cast-in-place concrete except that precast concrete base sections may be used for precast concrete manhole risers.

2.12.2 Precast Concrete Structures, Risers and Tops

In lieu of cast-in-place, Contractors, at their option, may provide precast concrete underground structures subject to the requirements specified below. Precast units shall be the product of a manufacturer regularly engaged in the manufacture of precast concrete products, including precast manholes.

2.12.2.1 General

Precast concrete structures shall have the same accessories and facilities as required for cast-in-place structures. Likewise, precast structures shall have plan area and clear heights not less than those of cast-in-place structures. Concrete materials and methods of construction shall be the same as for cast-in-place concrete construction, as modified herein. Slope in floor may be omitted provided precast sections are poured in reinforced steel forms. Concrete for precast work shall have a 28-day compressive strength of not less than 4000 psi. Structures may be precast to the design and details indicated for cast-in-place construction, precast monolithically and placed as a unit, or structures may be assembled sections, designed and produced by the manufacturer in accordance with the requirements specified. Structures shall be identified with the manufacturer's name embedded in or otherwise permanently attached to an interior wall face.

2.12.2.2 Design for Precast Structures

ACI 318M. In the absence of detailed on-site soil information, design for the following soil parameters/site conditions:

a. Angle of Internal Friction (phi) = 30 degrees

b. Unit Weight of Soil (Dry) = 110 pcf, (Saturated) = 130 pcf

c. Coefficient of Lateral Earth Pressure (Ka) = 0.33

d. Ground Water Level = 3 feet below ground elevation

e. Vertical design loads shall include full dead, superimposed dead, and live loads including a 30 percent magnification factor for impact. Live loads shall consider all types and magnitudes of vehicular (automotive) traffic to be encountered. The minimum design vertical load shall be for H20 highway loading per AASHTO HB-17.

f. Horizontal design loads shall include full geostatic and hydrostatic pressures for the soil parameters, water table, and depth of installation to be encountered. Also, horizontal loads imposed by adjacent structure foundations, and horizontal load components of vertical design loads, including impact, shall be considered, along with a pulling-in iron design load of 6000 pounds.

g. Each structural component shall be designed for the load combination and positioning resulting in the maximum shear and moment for that particular component.

h. Design shall also consider the live loads induced in the handling, installation, and backfilling of the manholes. Provide lifting devices to ensure structural integrity during handling and installation.

j. Comply with FS RR-F-621 Type VII for frame and Type 1 for cover

k. Interlocking, mating sections, complete with accessory items, hardware, and features as indicated. Include concrete knockout panels for conduit entrance and sleeve for ground rod.

l. Design structure according to ASTM C 858.

m. Structural Design Loading: ASTM C 857, Class A-16.

n. Fabricate according to ASTM C 858.

o. Joint Sealant shall be continuous extrusion of asphaltic butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand the maximum hydrostatic pressures at the installation location with the ground water level at grade.

p. Rigid PVC spacer type duct supports shall be selected to provide minimum duct spacings and concrete encasement indicated, while supporting ducts during concreting.

q. Cast iron with cast-in legend frames and covers shall be provided to meet Owner_fs labeling requirements.

r. Sump pump frame and grate to comply with FS RR-F-621 Type VII for frame and Type 1 for cover.

s. Pulling eyes in walls shall be eyebolt with reinforcing bar fastening insert. Eyebolt shall have a 2-inch diameter eye, with a 1 inch by 4 inch bolt. The working load embedding in a 6 inch, 4000 psi concrete shall be 13,000 pounds minimum tension.

t. Pulling and lifting irons shall be provided in the floor as required. These shall be 7/8-inch-diameter, hot-dipped galvanized, bent steel rod, stress relieved after forming, and fastened to reinforced rod. Exposed triangular opening. Ultimate yield strength: 40,000 pounds shear and 60,000 pounds tension.

u. The bolting inserts for cable stanchions shall be flared, threaded inserts of noncorrosive, chemical resistant, nonconductive thermoplastic material; .-inch internal diameter by 2-3/4 inches deep, flared to a 1-1/4 inch minimum at base. Tested ultimate pull-out strength: 12,000 pounds minimum.

v. Expansion anchors for installation after concrete is cast shall be zinc-plated carbon steel wedge type with stainless-steel expander clip inch bolt size, 5300 pound rated pullout strength and 6800 pound rated shear strength minimum.

w. Cable racks shall be heavy duty glass reinforced nylon construction nominal width of 4 inches, minimum height to be 36 inches or as required by installation conditions.

x. Cable arms shall be heavy duty glass reinforced nylon construction, nominal width of 4 inches. The length of the cable arm shall be 9, 14 or 20 inches as necessary for proper cable installation.

y. Ground rods shall be provided at each manhole, and these shall be solid copper clad steel, 3/4 inch diameter by 10 feet long. The grounding wire to the ground rods shall be stranded bare copper, number 6 AWG or as indicated or larger.

z. Duct sealing compound shall be non-hardening, safe for human skin contact, not deleterious to cable insulation, and workable at temperatures as low as 35 degrees Fahrenheit while withstanding temperature of 300 degrees Fahrenheit without slump, and while adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and the common metals

2.12.2.3 Construction
Structure top, bottom, and wall shall be of a uniform thickness of not less than 6 inches. Thin-walled knock-out panels for designed or future duct bank entrances shall not be permitted. Quantity, size, and location of duct bank entrance windows shall be as directed, and cast completely open by the precaster. Size of windows shall exceed the nominal duct bank envelope dimensions by at least 12 inches vertically and horizontally to preclude in-field window modifications made necessary by duct bank misalignment. However, the sides of precast windows shall be a minimum of 6 inches from the inside surface of adjacent walls, floors, or ceilings. Form the perimeter of precast window openings to have a keyed or inward flared surface to provide a positive interlock with the mating duct bank envelope. Provide welded wire fabric reinforcing through window openings for in-field cutting and flaring into duct bank envelopes. Provide additional reinforcing steel comprised of at least two No. 4 bars around window openings. Provide drain sumps a minimum of 12 inches in diameter and 4 inches deep for precast structures.

2.12.2.4 Joints
Provide tongue-and-groove joints on mating edges of precast components. Shiplap joints are not allowed. Design joints to firmly interlock adjoining components and to provide waterproof junctions and adequate shear transfer. Seal joints watertight using preformed plastic strip conforming to AASHTO M 198, Type B. Install sealing material in strict accordance with the sealant manufacturer's printed instructions. Provide waterproofing at conduit/duct entrances into structures, and where access frame meets the top slab, provide continuous grout seal.

2.12.3 Manhole Frames and Covers
Provide cast iron frames and covers for manholes conforming to CID A-A-60005. Cast the words "ELECTRIC" or "TELECOMMUNICATIONS" in the top face of power and telecommunications manhole covers, respectively. Manhole covers shall be inner seal type with a minimum diameter of thirty-six inches and designed for roadway use.

2.12.4 Handhole Frames and Covers

Frames and covers of steel shall be welded by qualified welders in accordance with standard commercial practice. Steel covers shall be rolled-steel floor plate having an approved antislip surface. Hinges shall be of wrought steel, 5 by 5 inches by approximately 3/16 inch thick, without screw holes, and shall be for full surface application by fillet welding. Hinges shall have nonremovable pins and five knuckles. The surfaces of plates under hinges shall be true after the removal of raised antislip surface, by grinding or other approved method.

2.12.5 Composite/Fiberglass Handholes and Covers
Provide handholes and covers of polymer concrete, reinforced with heavy weave fiberglass.
2.13 CABLE SUPPORTS (RACKS, ARMS, AND INSULATORS)

The metal portion of racks and arms shall be zinc-coated after fabrication.

2.13.1 Cable Racks

Cable racks shall be heavy-duty glass reinforced nylon construction nominal width of 4 inches, minimum height of 36 inches in manholes. Slots for mounting cable rack arms shall be spaced at 8 inch intervals.

2.13.2 Rack Arms

Cable rack arms shall be glass reinforced nylon and shall be of the removable type. Rack arm length shall be a minimum of 9 inches and a maximum of 20 inches.

2.13.3 Insulators

Insulators for metal rack arms shall be dry-process glazed porcelain. Insulators are not required for nylon arms.

2.14 CABLE TAGS IN MANHOLES

Provide tags for each power cable located in manholes. The tags shall be polyethylene. Do not provide handwritten letters. The first position on the power cable tag shall denote the voltage. The second through sixth positions on the tag shall identify the circuit. The next to last position shall denote the phase of the circuit and shall include the Greek "phi" symbol. The last position shall denote the cable size. As an example, a tag could have the following designation: "11.5 NAS 1-8(Phase A)500," denoting that the tagged cable is on the 11.5kV system circuit number NAS 1-8, underground, Phase A, sized at 500 kcmil.

2.14.1 Polyethylene Cable Tags

Provide tags of polyethylene that have an average tensile strength of 3250 pounds per square inch; and that are 0.08 inch thick (minimum), non-corrosive non-conductive; resistive to acids, alkalis, organic solvents, and salt water; and distortion resistant to 170 degrees F. Provide 0.05 inch (minimum) thick black polyethylene tag holder. Provide a one-piece nylon, self-locking tie at each end of the cable tag. Ties shall have a minimum loop tensile strength of 175 pounds. The cable tags shall have black block letters, numbers, and symbols one inch high on a yellow background. Letters, numbers, and symbols shall not fall off or change positions regardless of the cable tags' orientation.

2.15 SOURCE QUALITY CONTROL

2.15.1 Arc-Proofing Test for Cable Fireproofing Tape

Manufacturer shall test one sample assembly consisting of a straight lead tube 12 inches long with a 2 1/2 inch outside diameter, and a 1/8 inch thick wall, and covered with one-half lap layer of arc and fireproofing material per manufacturer's instructions. The arc and fireproofing tape shall withstand extreme temperature of a high-current fault arc 13,000 degrees K for 70 cycles as determined by using an argon directed plasma jet capable of constantly producing and maintaining an arc temperature of

13,000 degrees K. Temperature (13,000 degrees K) of the ignited arc between the cathode and anode shall be obtained from a dc power source of 305 (plus or minus 5) amperes and 20 (plus or minus 1) volts. The arc shall be directed toward the sample assembly accurately positioned 5 (plus or minus 1) millimeters downstream in the plasma from the anode orifice by fixed flow rate of argon gas (0.18 g per second). Each sample assembly shall be tested at three unrelated points. Start time for tests shall be taken from recorded peak current when the specimen is exposed to the full test temperature. Surface heat on the specimen prior to that time shall be minimal. The end point is established when the plasma or conductive arc penetrates the protective tape and strikes the lead tube. Submittals for arc-proofing tape shall indicate that the test has been performed and passed by the manufacturer.

2.15.2 Medium Voltage Cable Qualification and Production Tests

Results of AEIC CS8 qualification and production tests as applicable for each type of medium voltage cable.

2.15.2.1 Lightning Protection

A lightning protection system shall be provided for the facility, based upon the NFPA 780 Class 1 system, which is applicable for structures not exceeding 75 feet in height. The current system design is based upon a aluminum system, based upon aluminum and stainless steel building materials at roof level. Utilize solid 1/2-inch aluminum air terminals located on the roof, main conductors of 98.6 kCMIL or larger aluminum conductors, and 41.10 kCMIL or larger aluminum bonding conductors. The location of the air terminals and conductors shall be coordinated with the roof structure and design. The main conductors routed to the earth ground shall be installed in PVC conduit, concealed within the building structure and routed with regard to induced voltage and sideflash. Provide copper system if building materials at roof levels are more compatible with copper rather than aluminum lightning protection materials. Provide copper conductors within 30 inches of grade and provide proper UL listed aluminum to copper splicing devices to transition between the two conductor types. The lightning protection system shall protect the entire building, including roof projections, chimneys, and roof-mounted equipment. Each separate building shall be equipped with its own lightning protection system, e.g. Warehouse, VCC, etc. The installation of the lightning protection system shall be coordinated with the installation of other building systems, equipment and components, including electrical wiring, supporting structures and building materials, m

PART 3 EXECUTION

3.1 INSTALLATION

Install equipment and devices in accordance with the manufacturer's published instructions and with the requirements and recommendations of NFPA 70 and IEEE C2 as applicable. In addition to these requirements, install telecommunications in accordance with TIA-758-A and RUS Bull 1751F-644.

3.2 CABLE INSPECTION

Prior to installation, each cable reel shall be inspected for correct storage positions, signs of physical damage, and broken end seals. If end seal is broken, moisture shall be removed from cable prior to installation in accordance with the cable manufacturer's recommendations.

3.3 CABLE INSTALLATION PLAN AND PROCEDURE

The Contractor shall obtain from the manufacturer an installation manual or set of instructions which addresses such aspects as cable construction, insulation type, cable diameter, bending radius, cable temperature limits for installation, lubricants, coefficient of friction, conduit cleaning, storage procedures, moisture seals, testing for and purging moisture, maximum allowable pulling tension, and maximum allowable sidewall bearing

pressure. The Contractor shall then perform pulling calculations and prepare a pulling plan which shall be submitted along with the manufacturers instructions in accordance with SUBMITTALS. Cable shall be installed strictly in accordance with the cable manufacturer's recommendations and the approved installation plan.
Calculations and pulling plan shall include:

a. Site layout drawing with cable pulls identified in numeric order of expected pulling sequence and direction of cable pull.

b. List of cable installation equipment.

c. Lubricant manufacturer's application instructions.

d. Procedure for resealing cable ends to prevent moisture from entering cable.

d. Cable pulling tension calculations of all cable pulls.

e. Cable percentage conduit fill.

f. Cable sidewall bearing pressure.

h. Cable minimum bend radius and minimum diameter of pulling wheels used.

i. Cable jam ratio.

j. Maximum allowable pulling tension on each different type and size of conductor.

k. Maximum allowable pulling tension on pulling device.

3.3.1 3.3.1 Cable Instalation

3.3.1.1 Raceway Prepration

Prepare raceway and ensure that it is free of obstructions by means of the following minimum methods:

a. New and Existing Underground Raceway Preparation

(1) All mandrels shall be sized for the particular duct or raceway. Pull a flexible steel mandrel, consisting of nine steel discs in graduated sizes, completely through the duct.

(2) After the flexible mandrel has been pulled completed through the raceway, pull a heavy duty wire brush flexible steel mandrel, followed by a leather washer mandrel consisting of seven leather discs in graduated sizes, through the entire length of the raceway.

(3) After the leather washer mandrel has been pulled completed through the raceway, pull an aluminum test mandrel through the entire length of the raceway to test for out of round raceways.

b. Existing Aboveground Raceway Preparation: Pull a heavy duty wire brush mandrel through the entire length of the raceway.

c. Conductor Installation:

(1) Perform cable pulling tension and sidewall pressure calculations to determine optimum pulling set up and direction.

(2) Install medium-voltage cable as indicated, according to manufacturer's written instructions and IEEE Std 576.

(3) Install each feeder complete from source to load without the use of splices.

(4) Pull conductors simultaneously where more than one cable is indicated in same raceway. Do not exceed the manufacturer's minimum allowable conductor bending radii.

(a) Additional components might be required to perform the cable pull and shall be provided by the contractor as needed. All components shall be adequately rated (i.e. working load pounds plus applicable safety factors) for the pulling tensions required.

(b) Use a bell end feed for the conductors. Pre-lubricate the inside of the raceway by using Underwriter's Laboratories listed cable lubricant in a split bag dispenser attached ahead of the cable swivels. Continue to apply cable lubricant to the conductors as they enter the raceway and also apply cable lubricant to all eyes, swivels, connectors and conductors at all intermediate accessible locations such as pull boxes and manholes. Cable lubricants containing wax shall not be used. As basis of design cable lubricant shall be Polywater J (Polywater WJ for low temperatures), 3M WL-QT, or Condux SuperLube Other lubricants by other manufactures meeting specifications and providing equal or lower coefficients of friction are acceptable. Monitor the pulling tension throughout the entire pull

(c) The following two paragraphs apply, in addition to the other parts of this section, to pulls which cannot be performed by hand.

1) Use heavy duty power cable pulling eye attached to each conductor. Provide swivel connector between cable pulling eyes and multiple pulling harness eyes and between pulling harness leader ring and winch cable.

2) Use cable pulling machine with adjustable tension cut-out and continuous pulling tension recording. Set cut-out in accordance with power conductor manufacturer's suggested settings which will ensure that pulling tensions and sidewall pressures are not exceeded. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

d. Pull enough conductor length to allow 4 feet to be cut off of both ends of each conductor. Cut 4 feet off of conductor end when terminating or splicing the conductor. Cap and seal ends of conductors until actual time for terminating or splicing. Cut sufficient conductor to leave clean, undamaged end before terminating or splicing.

e. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit and support cables at intervals adequate to prevent sag.

3.4 UNDERGROUND FEEDERS SUPPLYING BUILDINGS

Terminate underground feeders supplying building at the terminating point indicated. Coordinate connections of the feeders to the service entrance equipment with Section 16402 INTERIOR DISTRIBUTION SYSTEM. Protect ends of underground conduit with plastic plugs until connections are made. Encase the underground portion of the conduit in a concrete envelope and bury as specified for underground duct with concrete encasement.

3.5 UNDERGROUND STRUCTURE CONSTRUCTION

Provide standard type cast-in-place construction as specified herein and as indicated, or precast construction as specified herein. Horizontal concrete surfaces of floors shall have a smooth trowel finish. Cure concrete by applying two coats of white pigmented membrane forming-curing compound in strict accordance with the manufacturer's printed instructions, except that precast concrete may be steam cured. Curing compound shall conform to ASTM C 309. Locate duct entrances and windows in the center of end walls (shorter) and near the corners of sidewalls (longer) to facilitate cable racking and splicing. Covers for underground structures shall fit the frames without undue play. Steel and iron shall be formed to shape and size with sharp lines and angles. Castings shall be free from warp and blow holes that may impair strength or appearance. Exposed metal shall have a smooth finish and sharp lines and arises. Provide necessary lugs, rabbets, and brackets. Set pulling-in irons and other built-in items in place before depositing concrete.

3.5.1 Cast-In-Place Concrete Structures

Construct walls on a footing of cast-in-place concrete except that precast concrete base sections may be used for precast concrete manhole risers.

3.5.2 Precast Concrete Construction

Set commercial precast structures on 6 inches of level, 90 percent compacted granular fill, 3/4 inch to 1 inch size, extending 12 inches beyond the structure on each side. Compact granular fill by a minimum of four passes with a plate type vibrator. Installation shall additionally conform to the manufacturer's instructions.

3.5.3 Pulling and Lifting Irons

Pulling and lifting irons shall be provided in the floor, as required. These shall be 7/8 inch diameter, hot-dipped galvanized, bent steel rod, stress relieved after forming and fastened to reinforced rod. Exposed triangular opening. Ultimate yield strength: 40,000 pounds shear and 60,000 pounds tension.

3.5.4 Pulling Eyes

Pulling eyes in walls shall be eyebolt with reinforcing bar fastening insert. Eyebolt shall have a 2 inch diameter eye, with a 1 inch by 4 inch bolt. The working load embedding in a 6 inch, 4,000 psi concrete shall be 13,000 pounds minimum tension.

3.5.5 Manhole Size Requirements

3.5.5.1 Power Manholes (Type 1)(Type 2)

Provide all power manoles with minimum inside clear dimensions of 8 feet wide x 10 feet long, x 7 feet high. Provide each manhole with 24 5 inch knockouts and 12 1.5 inch knockouts in each end and each side.

3.5.5.2 Communication Manholes (CMH)(Type 3)

Telecommunication manholes shall have minimum inside clear dimensions of 6 feet wide x 12 feet long x 7 feet high. These manholes shall have 24 4 inch duct terminations per side precast in walls with end bells. Provide Neehah Company, Model R-1751C, Series Lid and McGard Manhole Cover Lock P/N 117011 for CMH-03 and CMH-28. Lid and frame drilled and tapped to accept two mcGard Locking bolts 5/8 inch-11, P/N 117011.

3.5.5.3 Communication Manholes (CMH)(Type 4)

Telecommunication manholes shall have minimum inside clear dimensions of 5 feet wide x 8 feet wide x 7 feet high. These manholes shall have 12 precast 4 inch duct terminations in end walls for straight through polls only. Provide Neehah Company, Model R-1751C, Series Lid and McGard Manhole Cover Lock P/N 117011 for CMH-19, CMH-21, CMH-22, CMH-23, CMH-24, CHM-25, CHM-26, and CMH-27. Lid and frame drilled and tapped to accept two McGard Locking bolts 5/8 inch-11, P/N 117011.

3.5.5.4 Security Handholes (Type 5)

Provide concrete 4 feet wide x 4 feet long x 4 feet high security handholes with 12 precast 4 inch duct terminations in end walls.

3.5.5.5 Power Handholes (Type 6)

Handholes shall be molded fiberglass or polymer concrete 36 inches wide x 36 inches long x 18 inches high with six 4 inch conduit entrance knockouts at each side, with bottom, weatherproof cover with non-skid finish, and stainless steel hardware. Heads-of-bolts securing cover shall be 5-sided.

3.5.6 Cable Racks, Arms and Insulators

Cable racks, arms and insulators shall be sufficient to accommodate the cables. Racks in power manholes shall be spaced not more than 3 feet apart, and each manhole wall shall be provided with a minimum of two racks. Racks in signal manholes shall be spaced not more than 16 1/2 inches apart with the end rack being no further than 12 inches from the adjacent wall. Methods of anchoring cable racks shall be as follows:

a. Provide a 5/8 inch diameter by 5 inch long anchor bolt with 3 inch foot cast in structure wall with 2 inch protrusion of threaded portion of bolt into structure. Provide 5/8 inch steel square head nut on each anchor bolt. Coat threads of anchor bolts with suitable coating immediately prior to installing nuts.

b. Provide concrete channel insert with a minimum load rating of 800 pounds per foot. Insert channel shall be steel of the same length as "vertical rack channel;" channel insert shall be cast flush in structure wall. Provide 5/8 inch steel nuts in channel insert to receive 5/8 inch diameter by 3 inch long steel, square head anchor bolts.

c. Provide concrete "spot insert" at each anchor bolt location, cast flush in structure wall. Each insert shall have minimum 800 pound load rating. Provide 5/8 inch diameter by 3 inch long steel, square head anchor bolt at each anchor point. Coat threads of anchor bolts with suitable coating immediately prior to installing bolts.

3.5.7 Field Painting

Cast-iron frames and covers not buried in concrete or masonry shall be cleaned of mortar, rust, grease, dirt and other deleterious materials, and given a coat of bituminous paint.

3.6 UNDERGROUND CONDUIT AND DUCT SYSTEMS

3.6.1 Requirements

Depths to top of the conduit shall be in accordance with NFPA 70. Run conduit in straight lines except where a change of direction is necessary. Numbers and sizes of ducts shall be as indicated. Ducts shall have a continuous slope downward toward underground structures and away from buildings, laid with a minimum slope of 3 inches per 100 feet. Depending on the contour of the finished grade, the high-point may be at a terminal, a manhole, a handhole, or between manholes or handholes. Short-radius 90-degree duct bends may be used only for pole or equipment risers, unless specifically indicated as acceptable. The minimum bend radius shall be 18 inches for ducts of less than 3 inch diameter, and 36 inches for ducts 3 inches or greater in diameter. Otherwise, long sweep bends having a minimum radius of 25 feet shall be used for a change of direction of more than 5 degrees, either horizontally or vertically. Both curved and straight sections may be used to form long sweep bends, but the maximum curve used shall be 30 degrees. Ducts shall be provided with end bells whenever duct lines terminate in structures.

3.6.2 Treatment

Ducts shall be kept clean of concrete, dirt, or foreign substances during construction. Field cuts requiring tapers shall be made with proper tools and match factory tapers. A coupling recommended by the duct manufacturer shall be used whenever an existing duct is connected to a duct of different material or shape. Ducts shall be stored to avoid warping and deterioration with ends sufficiently plugged to prevent entry of any water or solid substances. Ducts shall be thoroughly cleaned before being laid. Plastic ducts shall be stored on a flat surface and protected from the direct rays of the sun.

3.6.3 Conduit Cleaning

As each conduit run is completed, for conduit sizes 3 inches and larger, draw a flexible testing mandrel approximately 12 inches long with a diameter less than the inside diameter of the conduit through the conduit. After which, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs. For conduit sizes less than 3 inches, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs.

3.6.4 Multiple Conduits

Separate multiple conduits by a minimum distance of 2 inches, except that light and power conduits shall be separated from telephone conduits by a minimum distance of 12 inches. Stagger thejoints of the conduits by rows (horizontally) and layers (vertically) to strengthen the conduit assembly. Provide plastic duct spacers that interlock vertically and horizontally. Spacer assembly shall consist of base spacers, intermediate spacers, ties, and locking device on top to provide a completely enclosed and locked-in conduit assembly. Install spacers per manufacturer's instructions, but provide a minimum of two spacer assemblies per 10 feet of conduit assembly.

3.6.5 Conduit Plugs and Pull Rope

New conduit indicated as being unused or empty shall be provided with plugs on each end. Plugs shall contain a weephole or screen to allow water drainage. Provide a plastic pull rope having 3 feet of slack at each end of all conduits.

3.6.6 Duct Encased in Concrete

Construct underground duct lines of individual conduits encased in concrete. Do not mix different kinds of conduit in any one duct bank. Concrete encasement surrounding the bank shall be rectangular in cross-section and shall provide at least 3 inches of concrete cover for ducts. Separate conduits by a minimum concrete thickness of 2 inches, except separate light and power conduits from telecommunications conduits by a minimum concrete thickness of 3 inches. Before pouring concrete, anchor duct bank assemblies to prevent the assemblies from floating during concrete pouring. Anchoring shall be done by driving reinforcing rods adjacent to duct spacer assemblies and attaching the rods to the spacer assembly. Provide color, type and depth of warning tape as specified in Section 02300 EARTHWORK.

3.6.6.1 Connections to Manholes

Duct bank envelopes connecting to underground structures shall be flared to have enlarged cross-section at the manhole entrance to provide additional shear strength. Dimensions of the flared cross-section shall be larger than the corresponding manhole opening dimensions by no less than 12 inches in each direction. Perimeter of the duct bank opening in the underground structure shall be flared toward the inside or keyed to provide a positive interlock between the duct bank and the wall of the structure. Use vibrators when this portion of the encasement is poured to assure a seal between the envelope and the wall of the structure.

3.6.6.2 Connections to Existing Underground Structures

For duct bank connections to existing structures, break the structure wall out to the dimensions required and preserve steel in the structure wall. Cut steel and bend out to tie into the reinforcing of the duct bank envelope. Chip the perimeter surface of the duct bank opening to form a key or flared surface, providing a positive connection with the duct bank envelope.

3.6.6.3 Partially Completed Duct Banks

During construction wherever a construction joint is necessary in a duct bank, prevent debris such as mud, and, and dirt from entering ducts by providing suitable conduit plugs. Fit concrete envelope of a partially completed duct bank with reinforcing steel extending a minimum of 2 feet back into the envelope and a minimum of 2 feet beyond the end of the envelope. Provide one No. 4 bar in each corner, 3 inches from the edge of the envelope. Secure corner bars with two No. 3 ties, spaced approximately one footapart. Restrain reinforcing assembly from moving during concrete pouring.

3.7 CABLE PULLING

Pull cables down grade with the feed-in point at the manhole or buildings of the highest elevation. Use flexible cable feeds to convey cables through manhole opening and into duct runs. Do not exceed the specified cable bending radii when installing cable under any conditions, including turnups into switches, transformers, switchgear, switchboards, and other enclosures. Cable with tape or wire shield shall have a bending radius not less than 12 times the overall diameter of the completed cable. If basket-grip type cable-pulling devices are used to pull cable in place, cut off the section of cable under the grip before splicing and terminating.

3.7.1 Cable Lubricants

Use lubricants that are specifically recommended by the cable manufacturer for assisting in pulling jacketed cables.

3.8 CABLES IN UNDERGROUND STRUCTURES

Do not install cables utilizing the shortest path between penetrations, but route along those walls providing the longest route and the maximum spare cable lengths. Form cables to closely parallel walls, not to interfere with duct entrances, and support on brackets and cable insulators. Support cable splices in underground structures by racks on each side of the splice. Locate splices to prevent cyclic bending in the spliced sheath. Install cables at middle and bottom of cable racks, leaving top space open for future cables, except as otherwise indicated for existing installations. Provide one spare three-insulator rack arm for each cable rack in each underground structure.

3.8.1 Cable Tag Installation

Install cable tags in each manhole as specified, including each splice. Tag wire and cable provided by this contract. Install cable tags over the fireproofing, if any, and locate the tags so that they are clearly visible without disturbing any cabling or wiring in the manholes.

3.9 CONDUCTORS INSTALLED IN PARALLEL

Conductors shall be grouped such that each conduit of a parallel run contains 1 Phase A conductor, 1 Phase B conductor, 1 Phase C conductor, and

1 neutral conductor.

3.10 LOW VOLTAGE CABLE SPLICING AND TERMINATING

Make terminations and splices with materials and methods as indicated or specified herein and as designated by the written instructions of the manufacturer. Do not allow the cables to be moved until after the splicing material has completely set. Make splices in underground distribution systems only in accessible locations such as manholes,handholes, or aboveground termination cabinets.

3.11 MEDIUM VOLTAGE CABLE TERMINATIONS

Make terminations in accordance with the written instruction of the termination kit manufacturer.

3.12 MEDIUM VOLTAGE CABLE JOINTS

Provide power cable joints (splices) suitable for continuous immersion in water. Make joints only in accessible locations in manholes or handholes by using materials and methods in accordance with the written instructions of the joint kit manufacturer.

3.12.1 Joints in Shielded Cables

Cover the joined area with metallic tape, or material like the original cable shield and connect it to the cable shield on each side of the splice. Provide a bare copper ground connection brought out in a watertight manner and grounded to the manhole grounding loop as part of the splice installation. Ground conductors, connections, and rods shall be as specified elsewhere in this section. Wire shall be trained to the sides of the enclosure to prevent interference with the working area.

3.13 CABLE END CAPS

Cable ends shall be sealed at all times with coated heat shrinkable end caps. Cables ends shall be sealed when the cable is delivered to the job site, while the cable is stored and during installation of the cable. The caps shall remain in place until the cable is spliced or terminated. Sealing compounds and tape are not acceptable substitutes for heat shrinkable end caps. Medium voltage cable which is not sealed in the specified manner at all times will be rejected.

3.14 FIREPROOFING OF CABLES IN UNDERGROUND STRUCTURES

Fireproof (arc proof) wire and cables which will carry current at 2200 volts or more in underground structures.

3.14.1 Fireproofing Tape

Tightly wrap strips of fireproofing tape around each cable spirally in half-lapped wrapping. Install tape in accordance with manufacturer's instructions.

3.15 GROUNDING SYSTEMS

Provide grounding system as indicated, in accordance with NFPA 70 and IEEE C2, and as specified herein. The overall ground grid resistance shall be less then 3 ohns.

Noncurrent-carrying metallic parts associated with electrical equipment shall have a maximum resistance to solid earth ground not exceeding the following values:

Pad-mounted transformers without protective fences	5 ohms
Ground in manholes	5 ohms
Grounding other metal enclosures of primary voltage electrical and electrically-operated equipment	5 ohms

3.15.1 Grounding Electrodes

Provide cone pointed driven ground rods driven full depth plus 6 inches, installed to provide an earth ground of the appropriate value for the particular equipment being grounded. If the specified ground resistance is not met, an additional ground rod shall be provided in accordance with the requirements of NFPA 70 (placed not less than 6 feet from the first rod). Should the resultant (combined) resistance exceed the specified resistance, measured not less than 48 hours after rainfall, the Contracting Officer shall be notified immediately.

3.15.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible, by exothermic weld or compression connector.

a. Make exothermic welds strictly in accordance with the weld manufacturer's written recommendations. Welds which are "puffed up" or which show convex surfaces indicating improper cleaning are not acceptable. Mechanical connectors are not required at exothermic welds.

b. Make compression connections using a hydraulic compression tool to provide the correct circumferential pressure. Tools and dies shall be as recommended by the manufacturer. An embossing die code or other standard method shall provide visible indication that a connector has been adequately compressed on the ground wire.

3.15.3 Grounding Conductors

Provide bare grounding conductors, except where installed in conduit with associated phase conductors. Ground cable sheaths, cable shields, conduit, and equipment with No. 6 AWG. Ground other noncurrent-carrying metal parts and equipment frames of metal-enclosed equipment. Ground metallic frames and covers of handholes and pull boxes with a braided, copper ground strap with equivalent ampacity of No. 6 AWG.

3.15.4 Ground Cable Crossing Expansion Joints

Protect ground cables crossing expansion joints or similar separations in structures and pavements by use of approved devices or methods of installation which provide the necessary slack in the cable across the joint to permit movement. Use stranded or other approved flexible copper cable across such separations.

3.15.5 Manhole Grounding

Loop a 4/0 AWG grounding conductor around the interior perimeter, approximately 12 inches above finished floor. Secure the conductor to the manhole walls at intervals not exceeding 36 inches. Connect the conductor to the manhole grounding electrode with 4/0 AWG conductor. Connect all incoming 4/0 grounding conductors to the ground loop adjacent to the point of entry into the manhole. Bond the ground loop to all cable shields, metal cable racks, and other metal equipment with a minimum 6 AWG conductor.

3.16 EXCAVATING, BACKFILLING, AND COMPACTING

Provide in accordance with NFPA 70 and Section 02300 EARTHWORK.

3.16.1 Reconditioning of Surfaces

3.16.1.1 Unpaved Surfaces

Restore to their original elevation and condition unpaved surfaces disturbed during installation of duct. Preserve sod and topsoil removed during excavation and reinstall after backfilling is completed. Replace sod that is damaged by sod of quality equal to that removed. When the surface is disturbed in a newly seeded area, re-seed the restored surface with the same quantity and formula of seed as that used in the original seeding, and provide topsoiling, fertilizing, liming, seeding, sodding, sprigging, or mulching.

3.16.1.2 Paving Repairs

Where trenches, pits, or other excavations are made in existing roadways and other areas of pavement where surface treatment of any kind exists , restore such surface treatment or pavement the same thickness and in the same kind as previously existed, except as otherwise specified, and to match and tie into the adjacent and surrounding existing surfaces.

3.17 CAST-IN-PLACE CONCRETE

Provide concrete in accordance with Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE.

3.17.1 Concrete Slabs for Equipment

Unless otherwise indicated, the slab shall be at least 8 inches thick, reinforced with a 6 by 6 - W2.9 by W2.9 mesh, placed uniformly 4 inches from the top of the slab. Slab shall be placed on a 6 inch thick, well-compacted gravel base. Top of concrete slab shall be approximately 4 inches above finished grade with gradual slope for drainage. Edges above grade shall have 1/2 inch chamfer. Slab shall be of adequate size to project at least 8 inches beyond the equipment. Stub up conduits, with bushings, 2 inches into cable wells in the concrete

pad. Coordinate dimensions of cable wells with transformer cable training areas.

3.17.2 Sealing

When the installation is complete, the Contractor shall seal all conduit and other entries into the equipment enclosure with an approved sealing compound. Seals shall be of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter.

3.17.2.1 Feeder Cable/Conduit Labeling

1. The Feeder conductors shall be labelled using in the format below. Example: 3-2C350-1C350-1C1/0-THHN-100-CN

2. Each section of text separated by dashes is a group. Each group has a dedicated meaning as shown in the table below.

3. Each group is subdivided into identifiers. Each identifier must follow the coding convention presented below.

- a. Phase Information:
  - i. Number of Phases
- b. Phase Conductor Information:
  - i. Number of Phase Conductors
  - ii. Conductor Material (shall follow the codes given below)
  - iii. Phase Conductor Size (shall follow the codes given below)
- c. Neutral Conductor Information:
  - i. Number of Neutral Conductors
  - ii. Conductor Material (shall follow the codes given below)
  - iii. Neutral Conductor Size (shall follow the codes given below)
- d. Ground Conductor Information:
  - i. Number of Ground Conductors
  - ii. Conductor Material (shall follow the codes given below)
  - iii. Ground Conductor Size (shall follow the codes given below)
- e. Insulation Type (shall follow the codes given below)
- f. % Insulation (shall follow the codes given below) (Only required for MV Cable)
- g. Shielding Type (shall follow the codes given below) (Only required for MV Cable)

4. Codes for “Conductor Size”
- a. 12 - #12 AWG
- b. 10 - #10 AWG
- c. 8 - #8 AWG
- d. 6 - #6 AWG
- e. 4 - #4 AWG
- f. 2 - #2 AWG
- g. 1 - #1 AWG
- h. 1/0 - 0 AWG
- i. 2/0 - 00 AWG
- j. 3/0 - 000 AWG
- k. 4/0 - 0000 AWG
- l. 250 - 250 kcmil
- m. 300 - 300 kcmil

- n. 350 - 350 kcmil
- p. 500 - 500 kcmil
- q. 600 - 600 kcmil
- r. 700 - 700 kcmil
- s. 750 - 750 kcmil
- t. 800 - 800 kcmil

u. 900 - 900 kcmil
v. 1000 - 1000 kcmil
w. 1250 - 1250 kcmil
x. 1500 - 1500 kcmil
y. 1750 - 1750 kcmil
z. 2000 - 2000 kcmil

5. Codes for “Conductor Material”
a. A – Aluminum
b. C – Copper
6. Codes for “Insulation Type”
a. FEP – Fluorinated Ethylene Propylene
b. FEPB – Fluorinated Ethylene Propylene
c. MI – Mineral Insulation
d. MTW – Moisture-, Heat-, and Oil-Resistant Thermoplastic
e. P – Paper
f. PFA – Perfluoro-alkoxy
g. PFAH – Perfluoro-alkoxy
h. RHH – Thermoset
i. RHW – Moisture-Resistant Thermoset
j. RHW2 – Moisture-Resistant Thermoset
k. SA – Silicone
l. SIS – Thermoset
m. TBS – Thermoplastic and Fibrous Outer Braid
n. TFE – Extended Polytetra-Fluoro-Ethylene
o. THHN – Heat-Resistant Thermoplastic
p. THHW – Moisture- and Heat-Resistant Thermoplastic
q. THW – Moisture- and Heat-Resistant Thermoplastic
r. THWN – Moisture- and Heat-Resistant Thermoplastic
s. TW – Moisture-Resistant Thermoplastic
t. UF – Underground Feeder and Branch-Circuit Cable (Single Conductor
u. USE – Underground Service Entrance Cable (Single Conductor)
v. XHH – Thermoset
w. XHHW – Moisture-Resistant Thermoset
x. XHHW2 – Moisture-Resistant Thermoset
y. Z – Modified Ethylene Tetrafluoro-Ethylene
z. ZW – Modified Ethylene Tetrafluoro-Ethylene
7. Codes for “% Insulation”
a. 100 – 100%
b. 133 – 133%
8. Codes for “Shielding Type”
a. CN – Concentric Neutral
b. SW – Spiral Wound
c. T – Tape

3.18 FIELD QUALITY CONTROL

3.18.1 Performance of Field Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.18.1.1 Medium Voltage Cables

Perform tests after installation of cable, splices, and terminators and before terminating to equipment or splicing to existing circuits.

a. Visual and Mechanical Inspection

(1) Inspect exposed cable sections for physical damage.
(2) Verify that cable is supplied and connected in accordance with contract plans and specifications.
(3) Inspect for proper shield grounding, cable support, and cable termination.
(4) Verify that cable bends are not less than ICEA or manufacturer's minimum allowable bending radius.
(5) Inspect for proper fireproofing.
(6) Visually inspect jacket and insulation condition.
(7) Inspect for proper phase identification and arrangement.

b. Electrical Tests

(1) Perform a shield continuity test on each power cable by ohmmeter method. Record ohmic value, resistance values in excess of 10 ohms per 1000 feet of cable must be investigated and justified.
(2) Medium-voltage cable insulation integrity tests shall be performed for cables. After installation and before the operating test or connection to an existing system, the medium-voltage cable system shall be given a high potential test. Direct-current voltage shall be applied on each phase conductor of the system by connecting conductors as one terminal and connecting grounds of metallic shieldings or sheaths of the cable as the other terminal for each test. Prior to making the test, the cables shall be isolated by opening applicable protective devices and disconnecting equipment. The test shall be conducted with all splices, connectors, and terminations in place. The method, voltage, length of time, and other characteristics of the test for initial installation shall be in accordance with NEMA WC 74 for the particular type of cable installed, and shall not exceed the recommendations of IEEE Std 404 cable joints and IEEE Std 48 for cable terminations. Should any cable fail due to a weakness of conductor insulation or due to defects or injuries incidental to the installation or because of improper installation of cable, cable joints, terminations, or other connections, the Contractor shall make necessary repairs or replace cables as directed. Repaired or replaced cables shall be retested.

3.18.1.2 Grounding System

a. Visual and mechanical inspection

Inspect ground system for compliance with contract plans and

Specifications

b. Electrical tests

Perform ground-impedance measurements utilizing the fall-of-potential method in accordance with IEEE Std 81. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable megohmmeter tester in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument shall be equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

3.18.2 Follow-Up Verification

Upon completion of acceptance checks and tests, the Contractor shall show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, the Contracting Officer shall be given 5 working days advance notice of the dates and times of checking and testing.

-- End of Section –

SECTION 16311
MAIN ELECTRIC SUPPLY STATION AND SUBSTATION
04/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C42.100 (2000) Standard Dictionary of Electrical and Electronics Terms

ANSI C62.2 (1987; R 1994) Guide for the Application of Gapped Silicon-Carbide Surge Arresters for Alternating Current Systems

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M (2006; Errata 2006) Structural Welding Code – Steel

ASME INTERNATIONAL (ASME)

ASME B31.3 (2004) Process Piping

ASME BPVC SEC IX (2004; 2005 Addenda; 2006 Addenda) Boiler and Pressure Vessel Code; Section IX, Welding and Brazing Qualifications

ASTM INTERNATIONAL (ASTM)

ASTM A 123/A 123M (2002) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A 153/A 153M (2005) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM B 117 (2003) Standing Practice for Operating Salt Spray (Fog) Apparatus

ASTM B 188 (2002) Standard Specification for Seamless Copper Bus Pipe and Tube

ASTM B 8 (2004) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

ASTM D 1654 (2005) Evaluation of Painted or Coated Specimens Subjected to Corrosive

Environments

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2005) National Electrical Safety Code
IEEE C37.04	(1999; R 2006) Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
IEEE C37.06	(2000) AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis - Preferred Ratings and Related Required Capabilities
IEEE C37.081	(1981; Supp 1997; R 2007) Guide for Synthetic Fault Testing of AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
IEEE C37.09	(1999) IEEE Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on aSymmetrical Current Basis
IEEE C37.2	(1996) Electrical Power System Device Function Numbers and Contact Designations
IEEE C37.20.2	(1999) Metal-Clad Switchgear
IEEE C37.90	(1994) Standard for Relays and Relay Systems Associated With Electric Power Apparatus
IEEE C57.12.01	(1998) General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid-Cast and/or Resin-Encapsulated Windings
IEEE C57.13	(1993; R 2003) Standard Requirements for Instrument Transformers
IEEE C57.15	(1999) Requirements, Terminology, and Test Code for Step-Voltage Regulators
IEEE C62.1	(1989; R 1994) Gapped Silicon-Carbide Surge Arresters for AC Power Circuits
IEEE C62.11	(1999) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)
IEEE Std 242	(2001) Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems - Buff Book
IEEE Std 399	(1997) Recommended Practice for Power Systems Analysis - Brown Book
IEEE Std 484	(2002) Recommended Practice for

	Installation Design and Implementation of Vented Lead-Acid Batteries for Stationary Applications
IEEE Std 485	(1997) Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications
IEEE Std 80	(2000) Safety in AC Substation Grounding
IEEE Std 81	(1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (Part 1)Normal Measurements

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2003) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA AB 1	(2002) Molded-Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures
NEMA C12.11	(1987; R 2002) Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV)
NEMA C29.1	(1988; R 2002) Test Methods for Electrical Power Insulators
NEMA LA 1	(1992; R 1999) Standard for Surge Arresters
NEMA PB 1	(2006) Standard for Panelboards
NEMA SG 6	(2000) Standard for Power Switching Equipment
NEMA WD 1	(1999; R 2005) Standard for General Requirements for Wiring Devices

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2005; TIA 2005) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 1236	(2006) Standard for Safety Battery Chargers for Charging Engine-Starter Batteries
UL 467	(2004) Standard for Grounding and Bonding Equipment
UL 489	(2004; Rev thru Jun 2006) Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 50	(2003; R 2005) Standard for Enclosures for

	Electrical Equipment
UL 6	(2004e13) Standard for Electrical Rigid Metal Conduit-Steel
UL 67	(1993; Rev thru Apr 2006) Standard for Panelboards

1.2 GENERAL REQUIREMENTS

1.2.1 Terminology

Terminology used in this specification is as defined in ANSI C42.100.

1.2.2 System Description

The system shall be configured as specified, and shall include structures, incoming and outgoing lines, circuit breakers, switches, switchgear, and appurtenances to provide a fully functional system.

1.2.3 Service Conditions

Items provided under this section shall be specifically suitable for the following service conditions. Seismic details shall conform to Sections 13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT, 15070 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT, and 16070 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

a. Fungus Control No

b. Altitude 1000 feet

c. Ambient Temperature 110 degrees F

d. Frequency 60 Hz

1.2.4 Incoming and Outgoing Circuit Compliance

Underground circuits shall comply with the requirements of Section 16302 UNDERGROUND ELECTRICAL DISTRIBUTION and in accordance with Georgia Power Company's INTERCONNECTION REQUIREMENTS AND PARALLEL OPERATION OF NON-UTILITY GENERATION No. 18-8..

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

General Installation Requirements

Detail Drawings

Detail drawings consisting of equipment drawings, illustrations, schedules, instructions, diagrams, and other information necessary to define the installation shall be submitted.

As-Built Drawings

The as-built drawings shall be a record of the construction as installed. The drawings shall include all the information shown on the contract drawings as well as all deviations, modifications, and changes from the contract drawings, however minor.

SD-03 Product Data

Support Structures

Manufacturer's design analysis and calculations for structures, foundations, anchor bolts, and supports differing from those indicated in the contract drawings, and for prefabricated structures. Calculations shall be made by a registered professional engineer with demonstrated experience in substation structural design in the last three years. The manufacturer shall provide a list of projects complete with points of contact, addresses and telephone numbers.

Fault Current Analysis

Protective Devices

Coordination Study

The study shall be submitted along with protective device equipment submittals. No time extensions or similar contract modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed shall be based on recommendations of this study. The Government shall not be held responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered and/or procured prior to approval of the study.

Battery

Calculations for the battery and associated charger indicating the basis used in defining loads, selecting cell types, and determining the battery ampere-hour capacity and physical size. Calculations shall be provided to determine capacity for the battery charger and be similar to those shown in the Appendix to IEEE Std 485, including explanatory data. Calculations for the battery-charger shall demonstrate that the output voltage and current provided are adequate to comply with the preceding requirements.

Nameplates

Submit data composed of catalog cuts, brochures, circulars, specifications, product data, and printed information in sufficient detail and scope to verify compliance with the requirements of the contract documents.

Material and Equipment

A complete itemized listing of equipment and materials proposed for incorporation into the work shall be submitted. Each entry shall include an item number, the quantity of items proposed, and the name of the manufacturer of each such item.

General Installation Requirements

As a minimum, the Contractor shall submit installation procedures for station buses and insulators, station structures, transformers, switchgear, battery system, voltage regulators and grounding resistors. Procedures shall include diagrams, instructions, and precautions required to install, adjust, calibrate, and test the devices and equipment.

Onsite Tests

A detailed description of the Contractor's proposed procedures for on-site tests.

SD-06 Test Reports

Factory Tests
Six copies of the information described below in 8 1/2 x 11 inch binders having a minimum of 5 rings from which material may readily be removed and replaced, including a separate section for each test. Sections shall be separated by heavy plastic dividers with tabs.

a. A list of all equipment used, with calibration certifications.

b. A copy of all measurements taken.

c. The dates of testing.

d. The equipment and values to be verified.

e. The condition specified for the test.

f. The test results, signed and dated.

g. A description of all adjustments made.

Field Testing

A detailed description of the Contractor's proposed procedures for on-site tests submitted 20 days prior to testing the installed system. No field test will be performed until the test plan is approved. The test plan shall consist of complete field test procedures including tests to be performed, test equipment required, and tolerance limits.

Field Test Reports

Six copies of the information described below in 8 1/2 x 11 inch binders having a minimum of 5 rings from which material may readily be removed and replaced, including a separate section for each test. Sections shall be separated by heavy plastic dividers with tabs.

a. A list of all equipment used, with calibration certifications.

b. A copy of all measurements taken.

c. The dates of testing.

d. The equipment and values verified.

e. The condition specified for the test.

f. The test results, signed and dated.

g. A description of all adjustments made.

h. Final position of controls, and device settings.

SD-07 Certificates

Material and Equipment

Where materials or equipment are specified to conform to the standards of the Underwriters Laboratories, Inc., (UL) or to be constructed or tested, or both, in accordance with the standards of the American National Standards Institute (ANSI), the Institute of Electrical and Electronics Engineers (IEEE), or the National Electrical Manufacturers Association (NEMA), the Contractor shall submit proof that the items provided under this section of the specifications conform to such requirements. The label of, or listing by, UL will be acceptable evidence that the items conform thereto. Either a certification or a published catalog specification data statement, to the effect that the item is in accordance with the referenced ANSI or IEEE standard, will be acceptable evidence that the item conforms thereto. A similar certification or published catalog specification data statement to the effect that the item is in accordance with the referenced NEMA standard, by a company listed as a member company of NEMA, will be acceptable evidence that the item conforms thereto. In lieu of such certification or published data, the Contractor may submit a certificate from a recognized testing agency equipped and competent to perform such services, stating that the items have been tested and that they conform to the requirements listed, including methods of testing of the specified agencies. Compliance with above-named requirements does not relieve the Contractor from compliance with any other requirements of the specifications.

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

Six copies of operation and maintenance manuals, within 7 calendar days following the completion of tests and including assembly, installation, operation and maintenance instructions, spare parts data which provides supplier name, current cost, catalog order number, and a recommended list of spare parts to be stocked. Manuals shall also include data outlining detailed procedures for system startup and operation, and a troubleshooting guide which lists possible operational problems and corrective action to be taken. A brief description of all equipment, basic operating features, and routine maintenance requirements shall also be included. Documents shall be bound in a binder marked or identified on the spine and front cover. A table of contents page shall be included and marked with pertinent contract information and contents of the manual. Tabs shall be provided to separate different types of documents, such as catalog ordering information, drawings, instructions, and spare-parts data. Index sheets shall be provided for each section of the manual when

warranted by the quantity of documents included under separate tabs or dividers.
Three additional copies of the instructions manual within 30 days following the approval of the manuals.

1.4 DELIVERY, STORAGE, AND HANDLING

Devices and equipment shall be visually inspected by the Contractor when received and prior to acceptance from conveyance. Stored items shall be protected from the environment in accordance with the manufacturer's published instructions. Damaged items shall be replaced. Oil filled transformers and switches shall be stored in accordance with the manufacturer's requirements.

1.5 EXTRA MATERIALS

Two complete sets of all special tools required for maintenance shall be provided, complete with a suitable tool box. Special tools are those that only the manufacturer provides, for special purposes (to access compartments, or operate, adjust, or maintain special parts).

1.6 DRAWINGS

1.6.1 Detail Drawings

Detail drawings shall show the ratings of items and systems and how the components of an item and system are assembled, function together, and how they will be installed on the project. Data and drawings for component parts of an item or system shall be coordinated and submitted as a unit. Data and drawings shall be coordinated and included in a single submission. Multiple submissions for the same equipment or system are not acceptable except where prior approval has been obtained from the Contracting Officer. In such cases, a list of data to be submitted later shall be included with the first submission. Detail drawings shall show physical arrangement, construction details, connections, finishes, materials used in fabrication, provisions for conduit or busway entrance, access requirements for installation and maintenance, physical size, electrical characteristics, foundation and support details, and equipment weight. Drawings shall be drawn to scale and/or dimensioned. Optional items shall be clearly identified as included or excluded. Detail drawings shall as a minimum include:

a. Switchgear.

b. Battery system including calculations for the battery and charger.

c. Station single line electrical diagrams including primary, metering, sensing and relaying, control wiring, and control logic.

d. Structural drawings shall be prepared to show the structural or physical features of major items of station equipment and components of equipment or equipment assemblies and structures, including foundations or other types of supports for equipment and conductors. Those drawings shall include accurately scaled or dimensioned outline and arrangement or layout drawings to show the physical size of station equipment and component parts of the equipment and the relative arrangement of components and any physical connection of related components. Weights of equipment and components of equipment assemblies shall be provided when required to verify the adequacy of design and proposed construction of foundations or other types of supports. Dynamic forces shall be stated for switching devices when such forces must be considered in the design of support structures. The appropriate detail drawings shall show the provisions for leveling, anchoring, and connecting all items of station equipment during installation, and shall include any recommendations made by the manufacturer of the equipment.

e. Electrical drawings shall include single-line and three-line diagrams of the station and station equipment, schematics or elementary diagrams of each electrical system; internal wiring and external connection diagrams of each electrical device when published by the manufacturer; wiring diagrams of cabinets, panels, units, or other separate mountings; interconnection diagrams that show the wiring between separate components of assemblies; external connection diagrams that show the termination of wiring routed between separate items of station equipment; internal wiring diagrams of equipment showing wiring as actually provided for this project. External wiring connections shall be clearly identified.

f. If departures from the contract drawings are deemed necessary by the Contractor, complete details of such departures, including changes in related portions of the project and the reasons therefore, shall be submitted with the detail drawings. Approved departures shall be made at no additional cost to the Government.

1.6.2 As-Built Drawings

The as-built drawings shall be kept at the job site and updated periodically. The as-built drawings shall be a full sized set of prints marked to reflect all deviations, modifications, and changes. The as-built drawings shall be complete and show the location, size, dimensions, part identification, and other information. Additional sheets may be added. Upon completion of the work, the Contractor shall submit three full sized sets of the marked prints to the Contracting Officer for approval. If upon review, the as-built drawings are found to contain errors and/or omissions, they will be returned to the Contractor for correction. The Contractor shall correct and return the as-built drawings to the Contracting Officer for approval within ten calendar days from the time the drawings are returned to the Contractor.

PART 2 PRODUCTS

Products shall conform to the following requirements. Items of the same classification shall be identical including equipment, assemblies, parts, and components.

2.1 STANDARD PRODUCT

Material and equipment shall be the standard product of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

2.2 NAMEPLATES

2.2.1 General

Each major component of this specification shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a nameplate securely attached to the equipment. Nameplates shall be made of noncorrosive metal. As a minimum, nameplates shall be provided for regulators, circuit breakers, capacitors, meters, switches, switchgear, and grounding resistors.

2.3 CORROSION PROTECTION

2.3.1 Aluminum Materials

Aluminum shall not be used.

2.3.2 Ferrous Metal Materials

2.3.2.1 Hardware

Ferrous metal hardware shall be hot-dip galvanized in accordance with ASTM A 153/A 153M and ASTM A 123/A 123M.

2.3.2.2 Equipment

Equipment and component items, including but not limited to transformer stations and ferrous metal luminaires not hot-dip galvanized or porcelain enamel finished, shall be provided with corrosion-resistant finishes which shall withstand 480 hours of exposure to the salt spray test specified in ASTM B 117 without loss of paint or release of adhesion of the paint primer coat to the metal surface in excess of 1/16 inch from the test mark. The scribed test mark and test evaluation shall be in accordance with ASTM D 1654 with a rating of not less than 7 in accordance with TABLE 1, (procedure A). Cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel or mill galvanized sheet steel shall be coated with a zinc rich paint conforming to the manufacturer's standard.

2.3.3 Finishing

Painting required for surfaces not otherwise specified and finish painting of items only primed at the factory shall be as specified in Section 09900 PAINTS AND COATINGS.

2.4 SUBSTATION EQUIPMENT

The installation shall be of the primary unit substation type. The initial capacity of the substation is based on the 55/65 degrees C self-cooled transformer capacity shown. The number of outgoing distribution feeders shall be as shown. Outgoing circuits shall be three-phase three-wire type. Outgoing circuit equipment shall be rated for a nominal voltage class of 15 kV and shall have a BIL of not less than 95 kV. Outgoing circuits shall

leave the station underground.

2.4.1 Primary Unit Substation Switchgear

Primary unit substations switchgear shall be arc restraint suitable for outdoor installation installed in a walk-in Enclosure.

2.4.1.1 Outgoing Section Equipment

Outgoing section equipment shall comply with the requirements of paragraph OUTGOING METAL-CLAD SWITCHGEAR.

2.4.2 Articulated Primary Unit Substation

2.4.2.1 Incoming Section Equipment

Incoming section equipment shall comply with the requirements in paragraph OUTGOING METAL-CLAD SWITCHGEAR.

2.4.2.2 Outgoing Section Equipment

Outgoing section equipment shall comply with the requirements of paragraph OUTGOING METAL-CLAD SWITCHGEAR.

2.5 OUTGOING METAL-CLAD SWITCHGEAR

Switchgear shall comply with NEMA SG 6 and IEEE C37.20.2 and shall be of the outdoor protected-aisle arc resistant type consisting of incoming line , tie, auxiliary compartments and feeder circuit breaker units. Compartments shall be provided to accommodate specified or indicated auxiliary equipment. The indicated number of active circuit breakers and equipped cubicles shall be provided. When two-high circuit breaker units are installed, equipped space units shall be provided when necessary to make adjacent sections equal in height. Units denoted as equipped space shall consist of items of equipment listed for the basic unit in NEMA SG 6, except the power circuit breaker shall not be provided. Current transformers, instruments, instrument switches, and relays shall be provided for equipped space or future units as shown. Continuous current rating of equipped space units shall match the most common basic breaker unit ampere rating used elsewhere in the associated switchgear unless otherwise indicated. Switchgear shall be vented according to the manufacturer's standard practice. Switchgear shall have relaying as shown. The control voltage shall be 125 V dc.

2.5.1 Ratings

Main buses shall be three-phase three-wire with a continuous current rating of 2000 amperes rms. Switchgear ratings at 60 Hz shall be in accordance with IEEE C37.06 and as follows:

Maximum voltage.................................12.47 kV

Nominal voltage class...........................15 kV

BIL...95 kV

Maximum symmetrical interrupting current.........as shown

Continuous current..............................as shown

2.5.2 Circuit Breakers

Circuit breakers shall comply with IEEE C37.04 and IEEE C37.06 and shall consist of items listed for such units in NEMA SG 6. Where indicated, bus or lug connections to mount field-installed, slip-on, medium-voltage cable terminations for cable entering from below and a bus throat for connection to the associated metal-enclosed bus shall be provided. Circuit breakers shall be of the vacuum drawout type having electrically charged, stored-energy mechanisms which are mechanically and electrically trip free. A means for manual charging of each trip mechanism shall be provided. Circuit breakers of the same ampere rating shall be interchangeable, both mechanically and electrically. Each circuit breaker shall have a cell-mounted switch assembly for control and interlocking. In addition to any contacts used or shown, each circuit breaker shall be provided with four spare auxiliary and cell contacts, two normally open and two normally closed, wired to interconnection terminals. Interconnection terminal blocks shall be wired to permit remote open and close operations of each circuit breaker and for other required exterior connections or connections between switchgear sections.

2.5.2.1 Vacuum Circuit Interrupters

Vacuum interrupters shall be hermetically-sealed in a high vacuum to protect contacts from moisture and contamination. Circuit breakers shall have provisions for maintenance slow closing of contacts and have a readily accessible contact wear indicator. Tripping time shall not exceed 5 cycles.

2.5.3 Buses

Copper bus shall comply with ASTM B 188. Bolted or pressure joints for main and ground buses, interconnections, and external connections to equipment shall be of the silver-to-silver or the silver-to-tin high-pressure type. Bolted connections shall have a minimum of two bolts, except for the ground bus where one bolt will suffice. Each nut on any bolted connection shall be secured with a belleville washer or other locking means torqued in accordance with manufacturer's recommendations. Bus supporting elements shall be bolted to switchgear enclosures and shall comply with IEEE C37.20.2.

2.5.3.1 Main Buses

Main buses and connections shall have at least the same short-circuit current rating as circuit breakers. Buses shall be copper.

2.5.3.2 Ground Buses

Uninsulated copper ground buses, not less than 2 x 1/4 inch in cross-sectional area, shall be provided for the full length of a switchgear lineup. Ground buses of aluminum are not acceptable. The short-circuit current rating of the ground bus shall be at least equal to the short circuit current rating of the primary bus. Compression indent type cable lugs shall be provided at each end of a ground bus for connection of copper ground cables.

2.5.3.3 Control Buses

Control buses shall be provided as necessary to supply power to control devices. Buses shall be supplied from low-voltage panelboards. Where one panelboard serves more than one bus, each group of units on each bus shall

be served by different branch circuit breakers. The low-voltage panelboard shall be served a control power transformers (CPT). The CPT shall be connected via fuses ahead of the main circuit breaker.

2.5.4 Control Power Transformers

Control power transformers shall comply with IEEE C57.12.01, shall be of the ventilated dry type, and shall provide 240/120 volt, single-phase electric power for station ac control power requirements. The transformer primary voltage rating shall be 12.47 kV and the transformer capacity shall be as indicated. The BIL rating shall equal or exceed the BIL rating of the switchgear. Transformer current-limiting primary fuses shall be drawout type and shall be interlocked with a secondary molded case circuit breaker provided as a part of the transformer installation. Molded case circuit breakers shall comply with NEMA AB 1. It shall not be possible to open the primary fuse compartment unless this secondary circuit breaker is in the open position. Construction shall be of the drawout type for either the complete assembly or for primary fuses only, according to the manufacturer's standard. Mechanical interlocks shall prevent removal of primary fuses, unless the associated assembly is in a drawout or disconnected position.

2.5.5 SUBSTATION AND SWITCHGEAR PROTECTIVE RELAYS

2.5.5.1 General

Solid-state or microprocessor-based protective relays shall be provided as shown and shall be of a type specifically designed for use on power switchgear or associated electric power apparatus. Protective relays shall conform to IEEE C37.90. Relays and auxiliaries shall be suitable for operation with the instrument transformer ratios and connections provided.

2.5.5.2 Construction

Relays shall be of the semi-flush, rectangular, back-connected, dustproof, switchboard type. Necessary test devices shall be incorporated within each relay and shall provide a means for testing either from an external source of electric power or from associated instrument transformers. Relays shall have necessary auxiliaries for proper operation. Relays and auxiliaries shall be suitable for operation with the instrument transformer ratios and connections provided.

2.5.5.3 Ratings

Relays shall be the manufacturer's standard items of equipment with appropriate ranges for time dial, tap, and other settings. Relay device numbers shall correspond to the function names and descriptions of IEEE C37.2.

2.5.5.4 Protection Relays

Protection relays shall be as follows:

a. Protection relays for main circuit breakers shall be or 3-phase, multifunction microprocessor based type with phase 50/51, ground 50/51, 67,25,27,59 and other features required to establish coordination and transfer scheme operation.

b. Protection relays for tie circuit breakers shall be multifunction microprocessor based type with phase 50/51, ground 50/51, and other features required to establish coordination and transfer scheme operation.

c. Phase overcurrent relays for feeder circuit breakers shall be multifunction microprocessor based type with phase 50/51, ground 50/51. Ground protection shall be provided by residual connection of current transformers.

2.5.5.5 Bus Differential and Lockout Relays

Bus differential relay, device 87B, shall be of the three-phase microprocessor based differential type suitable for protection of buses. Lockout relay, device 86B, shall be of a type which, when used in conjunction with the 87B relay, trips and locks out the indicated circuit breaker.

2.5.6 Control Switches

Control and instrument switches shall be of the rotary switchboard type rated for alternating-current operation at 600 volts, or direct-current operation at 250 volts for dc circuits, as applicable. Contacts shall be rated for not less than a continuous current of 20 amperes, shall be of the silver-to-silver type, and shall have positive means for maintaining contact. Each switch shall be provided with a black operating handle, and an escutcheon clearly marked to show each operating position. Switch identifications and handle positions shall be engraved on escutcheons or may be provided on separate nameplates. Escutcheon engravings shall be white on a black background or black on a white background. Switches for potential phase selection shall be provided with an oval handle. Switches provided for circuit breaker control and local-remote selector switches shall have a pistol-grip handle and a mechanical target to indicate the last operating position of the switch. Red and green circuit breaker position indication LED lights shall be installed immediately above each circuit breaker switch. Local-remote selector switches shall be provided only when shown or specified. Position indication lights shall be installed immediately above selector switches, with LED lights indicating remote control and local control.

2.5.7 Test Blocks and Accessories

Test blocks and their associated testing accessories shall be provided for testing of instruments and protective relays that require periodic testing or calibration in-place, but which are not equipped with integral testing features. Test blocks with covers shall be mounted near the base of the switchgear unit beneath the devices to be tested, and shall be provided with a nameplate Combination test blocks shall not exceed 10 poles. Current test blocks shall be the short-circuiting type. Test devices shall be provided for insertion into the associated test block to permit application of the proper current or potential source for testing and calibration. Test devices shall be rated not less than 20 amperes and 125 volts dc.

2.5.8 Specific Unit Requirements

In addition to the basic circuit breaker unit requirement listed in NEMA SG 6, each individual unit or section shall contain other devices as required for the application. The following requirements are not to be considered complete in every detail and miscellaneous equipment and devices necessary for correct operation, as indicated or specified, shall be provided as necessary. Protective relays, meters, and control switches shall be mounted on a unit or compartment door. Where space is not available for these devices, indicated devices may be installed on auxiliary compartment doors as shown.

2.5.8.1 Incoming Main Units

Units shall be coordinated with the requirements of the serving utility and shall include the following:

a. Three current transformers.

b. Three phase microprocessor based multifunction type protection relay with phase 50/51, ground 50/51, 67,67N, 25, 27, 59 and additional featyres reqyured for ciirdubatuib and transfer scheme.

i. One three-phase or three single-phase bus differential relays device 87B, and an auxiliary lockout relay, device 86B, arranged to trip and lock out the associated circuit breaker and other circuit breakers as indicated.

j. Three- phase secondary potential test blocks with associated test devices, quantity as shown.

k. Three- phase secondary current test blocks with associated test devices, quantity as shown.

2.5.8.2 Auxiliary Compartments

Control and instrument transformers and panelboards shall be provided and housed in compartments, unless otherwise noted, and shall supply control power and instrument voltage to each bus section of the switchgear lineup and remote devices as required. Compartments shall be provided with a hinged door. Any interconnection wiring and conduit needed to connect the switchgear lineup or other devices requiring control power or instrument voltage shall be provided and indicated on the detail drawings. Equipment items shall include the following:

a. Three potential transformers.

b. Control power transformer.

c. Low-voltage alternating-current panelboards and low-voltage direct-current panelboards with main and branch circuits as shown , located in the switchgear aisle where indicated, and with equipment as specified in paragraph AUXILIARY SUBSTATION EQUIPMENT.

2.5.8.3 Bus Tie Unit

The unit shall be electrically interlocked with incoming line units as indicated.

2.5.8.4 Feeder Units

Units shall be provided for the protection of outgoing feeder circuits and shall include the following:

a. Three current transformers. One ground sensor current transformer.

b. Three phase microprocessor based multifunction type protection relay with phase 50/51, ground 50/51 and additional featyres reqyured for ciirdubatuib and transfer scheme.

c. Three phase secondary current test blocks with associated test devices quantity as shown.

2.5.9 Miscellaneous Items

2.5.9.1 Space Heating and Ventilation

Space heaters shall be installed in each switchgear unit and auxiliary compartment in accordance with the manufacturer's standard practice and shall be sized to prevent condensation over an ambient temperature range of minus 20 to 104 degrees F. Aisle ventilation fans or air conditioning shall be provided where indicated.

2.5.9.2 Aisle Lighting

Fluorescent luminaires shall be a manufacturer's standard fixture installed in the switchgear aisle Luminaires shall be wired to three-way switches located at each end of the switchgear aisle.

2.5.9.3 Duplex Receptacles

Duplex receptacles shall be installed on each end wall of the switchgear aisle. Receptacles and receptacle plates shall be white in color. Receptacles shall be the two-pole, three-wire, grounded type rated at 15 amperes and 125 volts, NEMA WD 1 configuration 5-15R.

2.5.9.4 Lighting and Appliance Branch Circuit Panelboards

Lighting and appliance branch-circuit panelboards for the protection of the indicated low-voltage circuits shall be located as specified. Ratings of panelboard mains shall be compatible with the supply voltage to the panelboard.

2.5.10 Accessories

Accessories identified in NEMA SG 6 shall be provided for the inspection, testing, maintenance, and repair of circuit breakers, and shall include one set of any special tools, as necessary to repair and maintain circuit breakers and major switchgear components. Maintenance and testing accessories shall include, but are not limited to the following:

a. Hand crank for positioning of circuit breakers.

b. Transfer truck, for movement of circuit breaker units.

c. Test cabinet for closing and tripping of circuit breakers by electrical control operations.

d. Lifting and transfer device for two-high circuit breaker units.

2.5.11 Finish Color

Finish color of the switchgear shall comply with the requirements for cabinets specified in paragraph CABINETS AND ENCLOSURES.

2.6 INSTRUMENT TRANSFORMERS

2.6.1 General

Instrument transformers shall comply with NEMA C12.11 and IEEE C57.13. Instrument transformers shall be configured for mounting in/on the device to which they are applied. Polarity marks on instrument transformers shall be visually evident and shown on drawings.

2.6.2 Current Transformers

Unless otherwise indicated, bar, wound, or window-type transformers are acceptable; and except for window-type units installed over insulated buses, transformers shall have a BIL rating consistent with the rated BIL of the associated switchgear or electric power apparatus bushings, buses or conductors. Current transformers shall have the indicated ratios. The continuous thermal-current rating factor shall be not less than 1.5. Other thermal and mechanical ratings of current transformers and their primary leads shall be coordinated with the design of the circuit breaker and shall be not less than the momentary rating of the associated circuit breaker. Each terminal of each current transformer shall be connected to a short-circuiting terminal block in the circuit interrupting mechanism cabinet, power transformer terminal cabinet.

2.6.2.1 Current Transformers for Metal-Clad Switchgear

Single-ratio units, used for metering and relaying, shall have a metering accuracy class rating of B. Current transformers for the bus differential protection shall be C200 class.

2.6.3 Voltage Transformers

Voltage transformers shall have indicated ratios. Units shall have an accuracy class rating of 0.3. Voltage transformers shall be of the drawout type having current-limiting fuses in primary circuit. Mechanical interlocks shall prevent removal of fuses, unless the associated voltage transformer is in a drawout position.

2.7 AUXILIARY SUBSTATION EQUIPMENT

2.7.1 Station Battery

The station battery installation shall include a battery, battery racks, a battery charger, and protective equipment. The station battery installation shall be housed where indicated.

2.7.1.1 Battery

The battery shall consist of the required number of lead-calcium cells interconnected with proper connectors provided by the battery manufacturer to provide a nominal battery rating of 125 volts. Rubber or plastic numerals, of at least 1 inch in height, shall be provided by the battery manufacturer for field attachment to permit proper cell identification. The battery shall have an ampere-hour capacity equal to at least 125 percent of the station's direct-current requirements including normal continuous loads plus intermittent loads. Normal continuous load capacity shall be adequate for an 8-hour period. Intermittent load capacity shall be adequate so that at least three openings and three closings of each of the station's associated circuit breakers can occur in an 8-hour period with no more than three circuit breaker units simultaneously operating. Battery circuits shall be ungrounded. Batteries shall have a 20-year minimum life and a 5-year no cost replacement warranty.

2.7.1.2 Battery Racks

Battery racks shall have welded steel frames and rails finished with two coats of paint of a color matching the battery charger enclosure. Racks shall be no more than two tiers high and top tiers shall be low enough to permit maintenance to be done by personnel standing at floor level. Rails shall have a top covering of plastic or rubber at least 1/16 inch thick. Paint, rubber, and plastic shall resist corrosion and action of the electrolyte. The installation shall be provided with a portable hydrometer syringe and thermometer. Where recommended by the manufacturer, the installation shall include a cell lifter.

2.7.1.3 Battery Charger

The battery charger shall comply with UL 1236 and shall be a constant voltage, filtered, voltage-regulated, fully automatic type rated for full-float charging of the associated battery. The battery charger shall be convection cooled and suitable for operation on electric power supplied from the associated low-voltage alternating-current panelboard, shall have adequate capacity to fully recharge the associated depleted battery in not more than 8 hours while supplying normal direct-current loads, and shall have an efficiency of not less than 90 percent. The battery charger shall have input and output circuit breakers which automatically disconnect the battery charger when faults occur. The battery charger shall have an output ammeter and voltmeter, and equalizing-float selector switch, and an equalizing timer with a range of 0 to 24 hours. The battery charger enclosure shall be painted as specified for indoor cabinets in paragraph CABINETS AND ENCLOSURES and shall be provided with wall mounting brackets or shall be free-standing as required by its size and weight. A relay for sensing loss of alternating-current input, and an adjustable relay for sensing that the battery charger output voltage has fallen to a pre-set level, shall be installed on the battery charger to actuate the associated annunciator circuits. DC ground detector LED lights shall be provided.

2.7.1.4 Protective Equipment

Protective equipment required by IEEE Std 484 shall be provided and installed in a free-standing cabinet mounted where indicated or directed. The cabinet shall conform to paragraph CABINETS AND ENCLOSURES. Water facilities required shall be of the portable type consisting of one 5 gallon tank and one 1 quart basin. The tank shall have a removable screw top and a spigot. The basin shall be suitable for rinsing eyes or skin in case of acid spillage.

2.8 CABINETS AND ENCLOSURES

Cabinets and enclosures shall comply with NEMA 250 and shall be of galvanized steel, shall be provided with hinged doors, and shall be suitable for indoor or outdoor installation as indicated. Where locations are not indicated, cabinets shall be suitable for outdoor installation. Thickness of metal and outdoor construction shall be in accordance with UL 50. An indoor cabinet exterior shall have one finish coat and an outdoor cabinet exterior shall have two finish coats. Finish colors shall be manufacturer's standard dark gray or sky gray for outdoor cabinets and light gray for indoor cabinets, unless otherwise specified. The finish color of outdoor equipment shall be the same unless otherwise approved. Finish coats shall be applied over a prepared substrate. Each cabinet shall be a freestanding type or may be supported by attachment to an enclosure fence or a switchgear interior wall where located adjacent thereto. A concrete pad shall be provided to support any outdoor cabinet whose base extends to within 3 inches of grade level and pads shall extend at least 4 inches below grade.

2.9 MISCELLANEOUS

2.9.1 Duplex Receptacles

Duplex receptacles shall be white in color and provided where shown. Receptacles exposed to the weather shall be equipped with weatherproof covers or installed in weatherproof box with a hinged door or cover. Receptacles shall be of the ground fault circuit interrupter type, or the receptacles and receptacle circuits shall be protected by a ground fault circuit interrupter type of circuit breaker. Unless otherwise shown, receptacles shall conform to the NEMA WD 1 configuration 5-15R rated at 125 volts, 15 amperes and shall be the two-pole, three-wire grounding type. Wiring for outdoor receptacle circuits shall be not less than No. 12 AWG in size and suitable for installation in wet locations. Ground-fault circuit interrupting receptacles shall be provided in electrical rooms, mechanical rooms, bathrooms, kitchens, outdoors, in damp and wet locations, and as required by either the Electrical Code or the space usage.

2.9.2 Low-Voltage Power Circuit Breakers

2.9.2.1 Molded-Case Circuit Breakers

NEMA AB 1 and UL 489.

2.9.3 Wiring

Wiring between separate items of station equipment shall conform to the requirements of Section 16302 UNDERGROUND ELECTRICAL DISTRIBUTION. Solid wiring may be used for convenience outlets, heating elements, and lighting circuits. Otherwise, the minimum class of stranding shall be Class C. Class K stranding shall be used for wiring between items of equipment mounted on swinging panels or doors and items mounted on fixed panels or parts of fixed assemblies. The insulation type shall be the type SIS unless otherwise specified, indicated, or proposed and approved for use. The minimum wire gauge shall be No. 14 AWG, except No. 18 AWG may be used for circuits that use one ampere or less. Circuits rated less than 115 volts ac or 125 volts dc may be wired with wiring rated 300 volts-to-ground. Otherwise, all wiring shall be rated for 600 volts ac and 250 volts dc. Current transformer circuit wiring shall be not less than No. 10 AWG and red in color. Wire markers shall be affixed to each end of wires and shall contain wire number or designations shown on contract or detail drawings, or as otherwise approved. Wire numbers shall also be permanently marked on terminal block marking strips where wires are connected. Insulated-barrel, crimp-type, lugs shall be used. Insulated-barrel crimp type ring lugs shall be used for current transformer secondary circuits.

2.9.4 Danger Signs

One danger sign inscribed "DANGER-HIGH VOLTAGE" shall be permanently and securely mounted approximately 5 feet above finished grade on each outward side of the fence enclosure. Fasteners shall be of stainless steel. Signs shall be of metal and shall have letters of at least 3 inches in height.

Voltage warning signs shall comply with IEEE C2.

2.9.5 Concentric-Lay-Stranded Conductors

Copper conductors shall comply with ASTM B 8 for soft drawn copper.

2.9.6 Conduits, Rigid Metal

Conduits shall comply with UL 6.

2.9.7 Hardware

Ferrous metal threaded items shall comply with ASTM A 153/A 153M and miscellaneous nonthreaded items shall comply with ASTM A 123/A 123M. Other equivalent protective treatment, as required by ASTM A 123/A 123M or ASTM A 153/A 153M, or ferrous metals designed to meet ASTM Standards covering corrosion-resisting steel, will be permitted if approved in writing.

2.9.8 Padlocks

Padlocks shall comply with Section 08710 DOOR HARDWARE

2.9.9 Panelboards, Circuit-Breaker Type

Panelboards shall comply with NEMA PB 1, UL 50 and UL 67.

2.10 GROUNDING AND BONDING

2.10.1 Driven Ground Rods

Ground rods shall be copper-clad steel conforming to UL 67 not less than 5/8 inch in diameter by 10 feet in length.

2.10.2 Grounding Conductors

Grounding conductors shall be bare, except where installed in conduit with associated phase conductors. Insulated conductors shall be of the same material as the phase conductors and green color-coded, except that conductors shall be rated no more than 600 volts. Bare conductors shall be ASTM B 8 soft-drawn unless otherwise indicated. Aluminum is not acceptable.

2.11 SURGE ARRESTERS

Surge arresters shall comply with NEMA LA 1, IEEE C62.1, ANSI C62.2, and IEEE C62.11, and shall be provided as indicated. Arresters shall be station class, rated as shown. Arresters shall be equipped with mounting brackets for the indicated installations. Arresters shall be of the metal-oxide varistor or manufactures standard type suitable for outdoor installations.

2.12 COORDINATED POWER SYSTEM PROTECTION

Analyses shall be prepared to demonstrate that the equipment selected and system constructed meet the contract requirements for equipment ratings, coordination, and protection. They shall include a load flow analysis, a fault current analysis, and a protective device coordination study. The studies shall be performed by a registered professional engineer with demonstrated experience in power system coordination in the last three years. The Contractor shall provide a list of references complete with points of contact, addresses, and telephone numbers. The selection of the engineer is subject to the approval of the Contracting Officer.

2.12.1 Scope of Analyses

The fault current analysis, and protective device coordination study shall begin at: the source bus and extend down to system buses where fault availability is less than 10,000 amperes (symmetrical) for building/facility 208/120 volt buses volt level distribution.

2.12.2 Determination of Facts

The time-current characteristics, features, and nameplate data for each existing protective device shall be determined and documented. The Contractor shall coordinate with the commercial power company for fault current availability at the site.

2.12.3 Single Line Diagram

A single line diagram shall be prepared to show the electrical system buses, devices, transformation points, and all sources of fault current (including generator and motor contributions). A fault-impedance diagram or a computer analysis diagram may be provided. Each bus, device, or transformation point shall have a unique identifier. If a fault-impedance diagram is provided, impedance data shall be shown. Locations of switches, breakers, and circuit interrupting devices shall be shown on the diagram together with available fault data, and the device interrupting rating.

2.12.4 Fault Current Analysis

2.12.4.1 Method

The fault current analysis shall be performed in accordance with methods described in IEEE Std 242, and IEEE Std 399.

2.12.4.2 Data

Actual data shall be utilized in fault calculations. Bus characteristics and transformer impedances shall be those proposed. Data shall be documented in the report.

2.12.4.3 Fault Current Availability

Balanced three-phase fault, bolted line-to-line, and line-to-ground fault current values shall be provided at each voltage transformation point and at each power distribution bus. The maximum and minimum values of fault available at each location shall be shown in tabular form on the diagram or in the report.

2.12.5 Coordination Study

The study shall demonstrate that the maximum possible degree of selectivity has been obtained between devices specified, consistent with protection of equipment and conductors from damage from overloads and fault conditions. The study shall include a description of the coordination of the protective devices in this project. Provide a written narrative that describes: which devices may operate in the event of a fault at each bus; the logic used to arrive at device ratings and settings; situations where system coordination is not achievable due to device limitations (an analysis of any device curves which overlap); coordination between upstream and downstream devices; and relay settings. Recommendations to improve or enhance system reliability, and detail where such changes would involve additions or modifications to the contract and cost changes (addition or reduction) shall be provided. Composite coordination plots shall be provided on log-log graph paper.

2.12.6 Study Report

a. The report shall include a narrative describing: the analyses performed; the bases and methods used; and the desired method of coordinated protection of the power system.

b. The study shall include descriptive and technical data for protective devices proposed. The data shall include manufacturers published data, nameplate data, and definition of the fixed or adjustable features of the existing or new protective devices.

c. The report shall document utility company data including system voltages, fault MVA, system X/R ratio, time-current characteristic curves, current transformer ratios, and relay device numbers and settings; and existing power system data including time-current characteristic curves and protective device ratings and settings.

d. The report shall contain fully coordinated composite time-current characteristic curves for each bus in the system, as required to ensure coordinated power system protection between protective devices or equipment. The report shall include recommended ratings and settings of all protective devices in tabulated form.

e. The report shall provide the calculations performed for the analyses, including computer analysis programs utilized. The name of the software package, developer, and version number shall be provided.

2.13 FACTORY TESTS

Factory tests shall be performed, as follows, in accordance with the applicable publications and with other requirements of these specifications. The Contracting Officer shall be notified at least 14 days before the equipment is ready for testing. The Contracting Officer reserves the right to witness the tests.

a. High-Voltage Circuit Breakers: Manufacturer's standard tests in accordance with IEEE C37.09 and IEEE C37.081.

b. Relaying Current Transformers: Manufacturer's standard tests in accordance with IEEE C57.13.

c. Instrument Current Transformers: Manufacturer's standard tests in accordance with IEEE C57.13.

d. Voltage Regulators: Manufacturer's standard tests in accordance with IEEE C57.15.

e. Electrical Power Insulators: Manufacturer's standard tests in accordance with NEMA C29.1.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

Equipment and devices shall be installed and energized in accordance with the manufacturer's published instructions. Circuits installed in conduits or underground and splices and terminations for medium-voltage cable shall conform to the requirements of Section 16302 UNDERGROUND ELECTRICAL DISTRIBUTION. Secondary circuits installed in conduit on poles shall conform to the requirements of Section 16402 INTERIOR DISTRIBUTION SYSTEM.

3.1.1 Conformance to Codes

The installation shall comply with the requirements and recommendations of NFPA 70 and IEEE C2.

3.1.2 Concrete Pads

Concrete pads for pad-mounted electrical equipment shall be constructed as indicated. Tops of concrete pads shall be level and shall project four inches above finished floor paving or grade and sloped to drain. Conduits for primary, secondary, and grounding conductors shall be set in place prior to placing of concrete pads. Concrete work shall comply with the requirements of Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE. If the equipment primary compartment is not of sufficient height to allow the installation of the medium-voltage terminators, load break elbows or switches, the Contractor shall provide adequate space by providing a rectangular hole in the concrete pad below the primary compartment and/or a factory prefabricated steel adjustment ring around the entire perimeter of the base of the equipment. Steel rings shall be factory manufactured to fit the base of the equipment of which they support and shall be factory painted to match the equipment enclosure. Steel base rings shall be constructed using the same or greater thickness of steel as the equipment being supported. Concrete pads to support pad mounted electrical equipment shall be reinforced steel reinforcing rods. Where grounding electrode conductors are installed through concrete pads, PVC conduit sleeves shall be installed through the concrete to provide physical protection. When the installation is complete, the Contractor shall seal all conduit and other entries into the equipment housing with an approved sealing compound. Seals shall be of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, and foreign matter. All housekeeping pads or pads electrical equipment is mounted to shall conform to the equipment footprint and not exceed the equipment foot print by more than 2 inches.

3.1.3 Fire Extinguisher Storage

An outdoor cabinet for housing a Government-provided, hand-operated, self-expellent, carbon dioxide fire extinguisher of 10 to 15 pounds capacity for Class C fires shall be provided and located as approved. The cabinet shall have a glass cover door and be painted red.

3.1.4 Field Welding

Procedures and welders shall be qualified in accordance with AWS D1.1/D1.1M for structural welding and ASME BPVC SEC IX for welding of equipment. Welding procedures qualified by others, and welders and welding operators qualified by a previously qualified employer may be accepted as permitted by ASME B31.3. The Contracting Officer shall be notified 24 hours in advance of tests and the tests shall be performed at the work site if practical. The Contracting Officer shall be provided with a copy of qualifying procedures and a list of names and identification symbols of qualified welders and welding operators. The welder or welding operator shall apply his assigned symbol near each weld he makes as a permanent record. Structural members shall be welded in accordance with Section 05090 WELDING, STRUCTURAL.

3.1.5 Connections to Utility Lines

The Contractor shall coordinate the work with the Contracting Officer and shall provide final connections to the utility electric lines.

3.2 EQUIPMENT INSTALLATION

3.2.1 Equipment Finishes

Equipment shall be carefully installed so as not to scratch finishes. After installation, finished surfaces shall be inspected and scratches touched up with a finish provided by the manufacturer especially for this purpose.

3.2.2 Supports

Enclosures and enclosure supports shall be installed in accordance with manufacturer's instructions. Supports shall consist of anchored channels leveled and then embedded in the concrete foundation. Channels, anchors, shims, or other leveling items shall be installed in accordance with the recommendations of the equipment manufacturer.

3.2.3 Switchgear Leveling

After leveling items are correctly installed, switchgear lineups shall be out-of-plumb by not more than 1/4 inch for the entire length and width. Insertion or withdrawal of removable elements shall be easily accomplished, and component devices shall operate properly after the switchgear assembly is completely installed.

3.3 ELECTRICAL BUS CONNECTIONS

All bolted connections shall be torqued to the correct tightness. The Contractor shall establish a checklist to insure that bolted connections have been properly coated and correctly torqued.

3.4 GROUNDING

A grounding grid, consisting of the indicated configuration of bare copper conductors and driven ground rods shall be installed as shown on the drawings. Grounding grid shall comply with IEEE Std 80. Equipment frames of metal-enclosed equipment, medium-voltage cable terminations, chain-link fencing, metal-structures, and other noncurrent-carrying metal items shall be connected to the ground grid as shown. At least two connections shall be provided from a switchgear ground bus, to the ground grid. Fences shall be grounded at each fixed gate post, each corner post, and at intermediate posts as indicated. Each gate section shall be bonded to its gate posts with a 1/8 x 1 inch flexible braided copper strap and ground post clamps. Fence ground clamps shall be of a type that inhibits corrosion between metal parts. Outriggers shall be grounded as shown.

3.4.1 Grounding Electrodes

Grounding electrodes shall be as follows:

a. Driven rod electrodes - Unless otherwise indicated, ground rods shall be driven into the earth until the tops of the rods are approximately one foot below finished grade.

b. Grid grounding electrodes - A grid grounding electrode shall be installed as shown consisting of bare copper conductors installed 24 inches, plus or minus 3 inches, below the finished top of soil grade. Grid conductors shall be bonded to all rod electrodes, and to all other intersecting grid conductors. Grid conductors shall be sized as shown.

3.4.2 Grounding and Bonding Connections

Connections above grade shall be made by the fusion-welding process or with bolted solderless connectors, in compliance with UL 467, and those below grade shall be made by the fusion-welding process. Where grounding conductors are connected to aluminum-composition conductors, specially treated or lined copper-to-aluminum connectors suitable for this purpose shall be used.

3.4.3 Grounding and Bonding Conductors

Grounding and bonding conductors include all conductors used to bond transformer enclosures, equipment frames and structural members to the grounding grid. Grounding and bonding conductors shall be sized as shown. After being located to provide maximum physical protection, exposed grounding conductors shall be securely attached to structural supports at not more than two foot intervals with suitable fasteners. Bends greater than 45 degrees in ground conductors are not permitted. Routing of ground conductors through concrete should be avoided. When concrete penetration is necessary, nonmetallic conduit shall be cast flush with the points of concrete entrance and exit so as to provide an opening for the ground conductor, and the opening shall be sealed with a suitable compound after installation.

3.5 FIELD TESTING

3.5.1 General

Field testing shall be performed in the presence of the Contracting Officer. The Contractor shall notify the Contracting Officer 14 days prior to conducting tests. The Contractor shall furnish all materials, labor, and equipment necessary to conduct field tests. The Contractor shall perform all tests and inspections recommended by the manufacturer unless specifically waived by the Contracting Officer. The Contractor shall maintain a written record of all tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results. All field test reports will be signed and dated by the Contractor.

3.5.2 Safety

The Contractor shall provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. The Contractor shall replace any devices or equipment which are damaged due to improper test procedures or handling.

3.5.3 Ground-Resistance Tests

The resistance of the grounding grid shall be measured using the fall-of-potential method defined in IEEE Std 81. Soil resistivity in the area of the grid shall be measured concurrently with the grid measurements. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.

a. Single rod electrode - 25 ohms.

b. Grid electrode - 3 ohms.

3.5.4 Ground-Grid Connection Inspection

All below-grade ground-grid connections will be visually inspected by the Contracting Officer before backfilling. The Contractor shall notify the Contracting Officer 8 hours before the site is ready for inspection.

3.5.5 Protective Relays

Protective relays shall be visually and mechanically inspected, adjusted, tested, and calibrated in accordance with the manufacturer's published instructions. Relay settings shall be implemented in accordance with the coordination study. Relay contacts shall be manually or electrically operated to verify that the proper breakers and alarms initiate. Relaying current transformers shall be field tested in accordance with IEEE C57.13.

3.5.6 Pre-Energization Services

Calibration, testing, adjustment, and placing into service of the installation shall be accomplished by a manufacturer's product field service engineer or independent testing company with a minimum of two years of current product experience. No part of the electrical system shall be energized until all station grounding components have been tested and demonstrated to comply with the specified requirements. The following services shall be performed on the equipment listed below. These services shall be performed subsequent to testing but prior to the initial energization. The equipment shall be inspected to insure that installation is in compliance with the recommendations of the manufacturer and as shown on the detail drawings. Terminations of conductors at station buses and at major equipment shall be inspected to ensure the adequacy of connections. Bare and insulated conductors between such terminations shall be inspected to detect possible damage caused during installation. If factory tests were not performed on completed assemblies, tests shall be performed after the installation of completed assemblies. Components shall be inspected for damage during installation or shipment and to verify that packaging materials have been removed. Components capable of being both manually and electrically operated shall be operated manually prior to the first electrical operation. Components capable of being calibrated, adjusted, and tested shall be calibrated, adjusted, and tested in accordance with the instructions of the equipment manufacturer. Items for which such services shall be provided include, but are not limited to, are the following:

Battery, station.

Breakers, circuit.

Substation, primary unit.

Substation, primary unit, articulated.

Switchgear, metal-clad.

3.5.7 Operating Tests

After the installation is completed, and at such time as the Contracting Officer may direct, the Contractor shall conduct operating tests for approval. The equipment shall be demonstrated to operate in accordance with the requirements herein. An operating test report shall be submitted in accordance with paragraph TEST REPORTS.

3.6 MANUFACTURER'S FIELD SERVICE

3.6.1 Onsite Training

The Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total of 8 hours of normal working time and shall start after the system is functionally completed but prior to final acceptance tests. The course instruction shall cover pertinent points involved in operating, starting, stopping, servicing the equipment, as well as all major elements of the operation and maintenance manuals. Additionally, the course instructions shall demonstrate all routine maintenance operations. A VHS or DVD format video tape of the entire training session shall be submitted.

3.6.2 Installation Engineer

After delivery of the equipment, the Contractor shall furnish one or more field engineers, regularly employed by the equipment manufacturer to supervise the installation of the equipment, assist in the performance of the onsite tests, initial operation, and instruct personnel as to the operational and maintenance features of the equipment.

3.7 ACCEPTANCE

Final acceptance of the facility will not be given until the Contractor has successfully completed all tests and after all defects in installation material or operation have been corrected.

-- End of Section --

SECTION 16360
SECONDARY UNIT SUBSTATIONS
04/07

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A 780	(2001; R 2006) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM D 1535	(2006) Specifying Color by the Munsell System
ASTM D 709	(2001) Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2005) National Electrical Safety Code
IEEE C37.121	(1989; R 1995) American National Standard for Switchgear Unit Substations Requirements
IEEE C37.20.3	(2001) Metal-Enclosed Interrupter Switchgear
IEEE C37.90.1	(2002) Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
IEEE C57.12.01	(1998) General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid-Cast and/or Resin-Encapsulated Windings
IEEE C57.12.51	(1981; R 1998) Ventilated Dry-Type Power Transformers, 501 kVA and Larger, Three-Phase, with High-Voltage 601 to 34 500 Volts, Low-Voltage 208Y/120 to 4160 Volts
IEEE C57.12.80	(2002) Standard Terminology for Power and Distribution Transformers
IEEE C57.12.91	(2001) Test Code for Dry-Type Distribution and Power Transformers
IEEE C57.124	(1991) Recommended Practice for the

	Detection of Partial Discharge and the Measurement of Apparent Charge in Dry-Type Transformers
IEEE C57.13	(1993; R 2003) Standard Requirements for Instrument Transformers
IEEE C57.98	(1994) Guide for Transformer Impulse Tests
IEEE C62.11	(1999) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)
IEEE Std 100	(2000) The Authoritave Dictionary of IEEE Standards Terms

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2003) Acceptance Testing Specifications

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA C12.1	(2001) Electric Meters; Code for Electricity Metering
NEMA ICS 6	(2006) Standard for Industrial Controls and Systems Enclosures
NEMA LI 1	(1998) Industrial Laminated Thermosetting Products

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	2005; TIA 2005) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 467	(2004) Standard for Grounding and Bonding Equipment

1.2 RELATED REQUIREMENTS

Section 16081 APPARATUS INSPECTION AND TESTING applies to this section, with the additions and modifications specified herein.

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE Std 100.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. Submit the following in accordance with Section 01330 SUBMITTAL PROCEDURES:
In addition, submit in accordance with paragraph entitled "Coordinated Submittal Reviews" herein.

1.4.1 Coordinated Submittal Reviews

a. Submit remaining substation component submittals to Engineer of Record for approval. In addition, submit one set of transformer submittals for surveillance and to insure alignment of equipment and coordination for interconnections.

SD-02 Shop Drawings

Unit Substation Drawings; G

Transformer drawings; G

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Submittals shall include the nameplate data, size, and capacity. Submittals shall also include applicable federal, military, industry, and technical society publication references.

SD-03 Product Data

Fuse curves; G

Secondary unit substation excluding transformer data; G

Unit substation transformer (dry-type); G
Submittal shall include manufacturer's information for each component, device, and accessory provided with the transformer.

SD-06 Test Reports

Acceptance checks and tests; G

SD-07 Certificates

Transformer Losses; G

SD-09 Manufacturer's Field Reports

Unit substation transformer design tests (dry-type); G

Unit substation transformer routine and other tests (dry-type); G

SD-10 Operation and Maintenance Data

Unit substations, Data Package; G

SD-11 Closeout Submittals

Assembled Operation and Maintenance Manuals

Equipment test schedule; G

1.5 QUALITY ASSURANCE

1.5.1 Drawing Requirements

1.5.1.1 Unit Substation Drawings

Drawings shall include, but are not limited to the following:

a. An outline drawing, with front, top, and side views showing incoming, transformer, and outgoing sections. Include switchgear information from Section 16442 SWITCHBOARDS AND SWITCHGEAR as part of the total unit substation.

b. One-line diagram showing fused load interrupter switch, current transformers, meters, and ampere rating of bus bars.

c. Elementary diagrams and wiring diagrams with terminals identified, and indicating prewired interconnections between items of equipment and the interconnection between the items.

d. Provisions for future bus extension.

e. Time-current characteristic fuse curves (on full size logarithmic paper) for the load interrupter switch fuse.

1.5.1.2 Transformer Drawings

Drawings shall include, but are not limited to the following:

a. An outline drawing, with front, top, and side views.

b. ANSI nameplate data.

c. Dimensions and weights of entire transformer and of core and coil assembly.

1.5.2 Transformer Losses

Submit certification from the manufacturer indicating conformance with the paragraph entitled "Specified Transformer Losses". If tests on transformers of "basically the same design" are not available, provide written certification by manufacturer that transformers will meet the specified losses, and state what the losses will be. Submit report with transformer shop drawings and product data.

1.5.3 Substation Product Data

Submittal shall include manufacturer's information for each component, device, and accessory provided with the equipment.

1.5.4 Test Reports

Submit report of acceptance test results as specified by paragraph entitled "Field Quality Control."

1.5.5 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.5.5 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section. All electrical products shall be installed according to the manufactures instructions.

1.5.6.1 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.6 MAINTENANCE

1.6.1 Assembled Operation and Maintenance Manuals

Manuals shall be assembled in durable, hard covered, water resistant binders. The manual shall be assembled and indexed in the order noted in a table of contents. The contents of the assembled operation and maintenance manuals shall be as follows:

a. Manufacturer's O&M information required by the paragraph entitled, "SD-10 Operation and Maintenance Data."

   a. Catalog data required by the paragraph entitled, "SD-03 Product Data."

   b. Drawing required by the paragraph entitled, "SD-02 Shop Drawings."

   c. Price for spare parts and supply list

   d. Routine and field acceptance test reports

1.6.2 Operation and Maintenance Data

Submit operation and maintenance data in accordance with Section 01781 OPERATION AND MAINTENANCE DATA and as specified herein.

1.7 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

Products and materials not considered to be secondary unit substations and related accessories are specified in Section 16302 UNDERGROUND TRANSMISSION AND DISTRIBUTION or Section 16402 INTERIOR DISTRIBUTION SYSTEM.

2.2 SECONDARY UNIT SUBSTATION

Secondary Unit substations shall comply with IEEE C37.121 regardless of the kVA rating specified. Substation shall consist of incoming sections, transformer sections, and outgoing sections. All secondary unit substations shall have a lamacoid MIMIC bus indicating the configuration of the line up attached with Screws. Substations shall be subassembled and coordinated by one manufacturer and shall be shipped in complete sections ready for connection at the site. Where practicable, substation shall be shipped as one unit.

2.2.1 Incoming Sections

The incoming section shall consist of a metal-enclosed interrupter switchgear for connecting the incoming circuit through two fused load interrupter switches to the transformer. If required for proper connection and alignment, include a transition section with the incoming section. The two switches shall be mechanically interlocked to prevent both being closed at the same time.

2.2.1.1 Incoming Section Enclosure

The incoming section enclosure shall be NEMA ICS 6 Type; NEMA 1 enclosure. Paint enclosure, including bases, ASTM D 1535 light gray No. 61 or No. 49.

2.2.1.2 Cable Terminations

Provide medium voltage cable terminations as specified in Section 16302 UNDERGROUND TRANSMISSION AND DISTRIBUTION.

2.2.1.3 Surge Arresters

IEEE C62.11, rated 10 kV, metal-oxide-varistor, with resistance-graded gap. Arresters shall be equipped with mounting brackets suitable for the indicated installations.

2.2.1.4 Load Interrupter Switch

IEEE C37.20.3, UL listed and labeled load interrupter switchgear. Provide a three-pole, single-throw, deadfront, metal-enclosed, load interrupter switch with manual stored energy operator. Switch shall be fused, with fuses mounted on a single frame and designed for easy inspection and fuse replacement. The switch shall be operated by a manually charged spring stored energy mechanism which shall simultaneously disconnect or connect

ungrounded conductors. The moveable blade of the switch shall be deenergized when in the open position. The mechanism shall enable the switch to close against a fault equal to the momentary rating of the switch without affecting its continuous current carrying or load interrupting ability. A ground bus shall extend the width of the switch enclosure and shall be bolted directly thereto. Connect frame of unit to ground bus. The door shall have an inspection window to allow full view of the position of the three switch blades through the closed door. Switch shall have provision for padlocking in the open and closed positions. Switch/fuse integrated ratings shall be as follow:

Rated Maximum Voltage, kV	Rated Withstand Impulse Voltage, kV BIL	Continuous and Load Interrupting Current, A	Short-Circuit Current kA rms Sym	Short-Time/ Fault-Close Current kA
15	95	600	38	40

Fuses shall be current limiting type rated approximately 150 percent of the transformer full-load rating and in accordance with the fuse manufacturer's recommendation and the protection and coordination study.

2.2.1.5 Primary Protective Device Connection

Connections between the primary protective device and transformer shall be cable mounted on porcelain insulators, and sized and braced to withstand the specified short-circuit and short-time currents.

2.2.2 Transformer (Dry-Type) Sections

IEEE C57.12.51 for dry-type transformers rated 501 kVA and larger. Provide a vacuum pressure impregnated (VPI) type transformer with an insulation system rated 220 degrees C, and with an 80 degree C average winding temperature rise above a 40 degrees C maximum ambient.

2.2.2.1 Transformer Ratings

a. Shall be rated 2500 kVA, 95 kV BIL Primary and 10 kV BIL Secondary.

b. Transformer voltage ratings: 12,470 Volt; 3 phase, 3 wire primary and a - 480Y/277 Volt; 3 phase, 4 wire, solidly grounded secondary.

c. Provide four 2.5 percent full capacity taps, two above and two below rated primary voltage. Locate tap adjustments on the face of the high voltage coil. Adjustments shall be accessible by removing the front panel and shall be made when the transformer is de-energized.

d. Minimum tested impedance shall be between 5.0 and 7.5 percent at 80 degrees C.

e. Audible sound levels shall comply with the following:

kVA	DECIBELS (MAX)
2500	68

f. Diagrammatic stainless steel or laser-etched anodized aluminum nameplate

g. Transformer shall include ground pads, lifting lugs and provisions for jacking under base. The transformer base construction shall be suitable for using rollers or skidding in any direction. The transformer shall have an insulated low-voltage neutral bushing with lugs for ground cable, and with removable ground strap.

h. Dry type transformer shall have the following accessories.

1. Winding temperature indicator

2. Auxiliary cooling equipment and controls

(a) Transformer shall be forced-air-cooled. Forced-air-cooling fans shall be controlled by an automatic temperature control relay and winding temperature indicator with sequence contacts.

2.2.3 Outgoing Section

The outgoing section shall consist of a full height air terminal compartment for physical protection of and connection point for the secondary conductors between the transformer and the switchgear shall be as specified in Section 16442 SWITCHBOARDS AND SWITCHGEAR.
2.T2h.e3 .b1u s tBiues cTiirecuit breakers shall be configured to allow for a closed transition switching operations between associated tripple ended substation buses.

2.2.4 Watthour and Digital Meters

2.2.4.1 Digital Meters

IEEE C37.90.1 for surge withstand. Provide true rms, plus/minus one percent accuracy, programmable, microprocessor-based meters enclosed in sealed cases with a simultaneous three line display. Meters shall have 0.56 inch, minimum, LED OR LCD characters. The meters shall accept input from standard 5A secondary instrument transformers. Programming shall be via a front panel display and a communication interface with a computer. Password secured programming shall be stored in non-volatile EEPROM memory. Digital communications shall be Modbus RTU protocol via an RS485 serial port and an independently addressable RS485 serial port. The meter shall calculate and store average max/min demand values for all readings based on a user selectable sliding window averaging period. The meter shall have programmable hi/low set limits with two Form C dry contact relays when exceeding alarm conditions. Meter shall provide THD measurement to the thirty-first order. Historical trend logging capability shall include ability to store up to 100,000 data points with intervals of 1 second to 180 minutes. The unit shall also store and time stamp up to 100 programmable triggered conditions. Event waveform recording shall be triggered by the rms of 2 cycles of voltage or current exceeding programmable set points. Waveforms shall be stored for all 6 channels of voltage and current for a minimum of 10 cycles prior to the event and 50 cycles past the event.The latest version of ION-7700 series is the preferred choice.

a. Multifunction Digital Metering Unit: UL listed or recognized microprocessor-based unit suitable for three- or four-wire systems and

with the following features:

1) Inputs and Ranging: From sensors or current transformers from 50/5 through 6000/5 ratings and voltage sensing terminals capable of directly accepting up to 600 volts, and scaled 120V input from voltage transformers of up to 1000:1 ration.

2) Data Holding: Unit shall continue to accumulate and retain data for control power outages up to one week in duration.

3) Display: Switch selectable digital display allowing display of the following values with maximum accuracy tolerances as indicated:

Multifunction Digital Metering Unit

Parameter	Display Accuracy	Notes
Each Phase Current	Plus or minus 1 percent, plus or minus 1 digit	Provide ability to display minimum and maximum values since last reset.
Average Phase Current	Plus or minus 1 percent, plus or minus 1 digit	
Phase-to-Phase Voltages	Plus or minus 1 percent, plus or minus 1 digit	Provide ability to display minimum and maximum values since last reset.
Each Phase-to-Neutral Voltage	Plus or minus 1 percent, plus or minus 1 digit	
Real Power	Plus or minus 1 percent, plus or minus 1 digit	Provide ability to display minimum and maximum values since last reset and ability to display kilowatts or megawatts
Reactive Power	Plus or minus 1 percent, plus or minus 1 digit	Provide ability to display minimum and maximum values since last reset and ability to display kilovars or megavars
Accumulated Energy	Plus or minus ½ percent, plus or minus 1 digit	Provide ability to display minimum and maximum values since last reset and ability to display kilowatt-hours or megawatt-hours
Real Demand	Plus or minus 1 percent, plus or minus 1 digit	Provide ability to display kilowatts or megawatts. Demand

Multifunction Digital Metering Unit

		interval shall be programmable from 5

		minutes to one hour, with the ability to select a fixed or sliding-window demand interval
Harmonic Current and Harmonic Voltage	Plus or minus 2 percent, plus or minus 1 digit	Display Total Harmonic Distortion for Current and Voltage with ability to display minimum and maximum values since last reset. Calculate up to the 39th harmonic.
Power Factor	Plus or minus 2 percent, plus or minus 1 digit	Provide ability to display minimum and maximum values since last reset.
Frequency	Plus or minus 0.1 percent, plus or minus 1 digit	Provide ability to display minimum and maximum values since last reset.

4) Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

2.2.5 Current Transformers

IEEE C57.13. Transformers shall be single ratio, 60 hertz, ratio as indicated on drawings. Minimum of 2.0 rating factor, with a metering accuracy class of 0.3 at rated burden.

2.2.6 Control Power Transformers

Transformer shall conform to the requirements of Section 16402 INTERIOR DISTRIBUTION SYSTEM.

2.2.7 Meter Fusing

Provide a fuse block to mounted in the metering compartment containing one fuse per phase to protect the voltage input to voltage sensing meters. Size fuses as recommended by the meter manufacturer.

2.2.8 Test Blocks

Provide voltage and shorting type current test blocks in metering circuit and locate on front of secondary unit substation.

2.2.9 Insulated Barriers

Where insulated barriers are required by reference standards, provide barriers in accordance with NEMA LI 1, Type GPO-3, 0.25 inch minimum thickness.

2.2.10 Terminal Boards

Provide with engraved plastic terminal strips and screw type terminals for external wiring between components and for internal wiring between removable assemblies. Terminal boards associated with current transformers shall be short-circuiting type. Terminate conductors for current transformers with ring-tongue lugs. Terminal board identification shall be identical in similar units.

2.2.11 Wire Marking

Mark control and metering conductors at each end. Provide factory-installed, white, plastic tubing, heat stamped with black block type letters on factory-installed wiring. On field-installed wiring, provide white, preprinted, polyvinyl chloride (PVC) sleeves, heat stamped with black block type letters. Each sleeve shall contain a single letter or number, shall be elliptically shaped to securely grip the wire, and shall be keyed in such a manner to ensure alignment with adjacent sleeves. Provide specific wire markings using the appropriate combination of individual sleeves. Each wire marker shall indicate the device or equipment, including specific terminal number to which the remote end of the wire is attached.

2.2.12 Grounding and Bonding

Provide as specified in Section 16302 UNDERGROUND TRANSMISSION AND DISTRIBUTION.

2.2.13 Cast-in-Place Concrete

Concrete associated with electrical work for other than encasement of underground ducts shall be 4000 psi minimum 28-day compressive strength unless specified otherwise. All concrete shall conform to the requirements of Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE.

Shall be composed of fine aggregate, coarse aggregate, portland cement, and water so proportioned and mixed as to produce a plastic, workable mixture. Fine aggregate shall be of hard, dense, durable, clean, and uncoated sand. The coarse aggregate shall be reasonably well graded from 3/16 inch to one inch. The fine and coarse aggregates shall be free from injurious amounts of dirt, vegetable matter, soft fragments or other deleterious substances. Water shall be fresh, clean, and free from salts, alkali, organic matter, and other impurities. Concrete associated with electrical work for other than encasement of underground ducts shall be 4000 psi minimum 28-day compressive strength unless specified otherwise. Slump shall not exceed 4 inches. Retempering of concrete will not be permitted. Exposed, unformed concrete surfaces shall be given a smooth, wood float finish. Concrete shall be cured for a period of not less than 7 days, and concrete made with high early strength portland cement shall be repaired by patching honeycombed or otherwise defective areas with cement mortar as directed by the Contracting Officer.

2.3 MANUFACTURER'S NAMEPLATES

Each item of equipment shall have a nameplate bearing, as a minimum, the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable. Include additional information as applicable to fully identify the equipment. Nameplates shall be made of noncorrosive metal. Sectionalizer switch nameplates shall have a schematic with all switch positions shown and labeled. As a minimum, provide nameplates for transformers, circuit breakers, meters, switches, and switchgear.

2.4 FIELD FABRICATED NAMEPLATES

ASTM D 709. Provide laminated plastic nameplates for each secondary unit substation, equipment enclosure, relay, switch, and device; as specified in this section or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 0.125 inch thick, white with black center core. Provide red laminated plastic label with white center core where indicated. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be one by 2.5 inches. Lettering shall be a minimum of 0.25 inch high normal block style.

2.5 WARNING SIGNS

Provide warning signs for the enclosures of secondary unit substations having a nominal rating exceeding 600 volts.

2.6 SOURCE QUALITY CONTROL

2.6.1 Equipment Test Schedule

The Government reserves the right to witness tests. Provide equipment test schedules for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 30 calendar days before scheduled test date. Notify Contracting Officer 15 calendar days in advance of changes to scheduled date.

a. Test Instrument Calibration

1. The manufacturer shall have a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

2. The accuracy shall be directly traceable to the National Institute of Standards and Technology.

3. Instrument calibration frequency schedule shall not exceed 12 months for both test floor instruments and leased specialty equipment.

4. Dated calibration labels shall be visible on all test equipment.

5. Calibrating standard shall be of higher accuracy than that of the instrument tested.

6. Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:

(a) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

(b) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

2.6.2 Load Interrupter Switch Production Tests

IEEE C37.20.3. Furnish reports of production tests performed on the actual equipment for this project. Required tests shall be as follows:

a. Production Tests

1. Dielectric

2. Mechanical operation

3. Grounding of instrument transformer case

4. Electrical operation and control wiring

2.6.3 Transformer Design Tests (Dry-Type)

In accordance with IEEE C57.12.01 and IEEE C57.12.91. Additionally, IEEE C57.12.80 section 5.1.2 states that "design tests are made only on representative apparatus of basically the same design." Submit design test reports in the same submittal package as the product data, shop drawings, and certificates of transformer losses for each of the specified transformers. Design tests shall have been performed prior to the award of this contract.

a. Provide required submittals in a hard-covered binder with index and tabs.

b. Tests shall be certified and signed by a registered professional engineer. Engineers stamp and signature shall appear on at least the first page of the factory test reports.

c. Temperature rise:

1. "Basically the same design" for the temperature rise test means a unit-substation transformer with the same coil construction (such as wire wound primary and sheet wound secondary), the same kVA, the same cooling type (AA), the same temperature rise rating, the same insulating class and the same insulating medium as the transformer specified.

2. Provide temperature rise readings, formulas, calculations of average temperature rise, and description of test method.

d. Lightning impulse:

1. "Basically the same design" for the lightning impulse dielectric test means a unit-substation transformer with the same BIL and the same coil construction (such as wire wound primary and sheet wound secondary).

2. IEEE C57.12.91 and IEEE C57.98. Provide design lightning impulse tests consisting of a reduced full-wave, two-chopped waves, and one full wave test for each phase of the primary and secondary windings of the same transformer.

3. State test voltage levels.

4. Provide photographs of oscilloscope display waveforms or plots of

digitized waveforms with test report.

5. Partial Discharge Test per IEEE C57.124. Provide transformer ratings, description and diagram of test method used, test readings and final results.

2.6.4 Transformer Routine and Other Tests (Dry-Type)

In accordance with IEEE C57.12.01 and IEEE C57.12.91. Routine and other tests shall be performed by the manufacturer on each of the actual transformers prepared for this project to ensure that the design performance is maintained in production. Submit test reports, by serial number and receive approval before delivery of equipment to the project site. Required tests and testing sequence shall be as follows:

a. Resistance measurements

b. Phase relation

c. Ratio

d. Insulation power-factor by manufacturer's recommended test method.

e. No-load losses (NLL) and excitation current

f. Load losses (LL) and impedance voltage

g. Lightning impulse: Perform the complete design type impulse tests on the transformer primary winding only.

1. IEEE C57.12.91 and IEEE C57.98

2. State test voltage levels

3. Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test reports. As an alternative, photographs of oscilloscope display waveforms or plots of digitized waveforms may be hand delivered at the factory witness test.

g. Low frequency dielectric

1. Applied voltage
2. Induced voltage

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations shall conform to IEEE C2, NFPA 70, and to the requirements specified herein.

3.2 GROUNDING

NFPA 70 and IEEE C2, except that grounds and grounding systems shall have a resistance to solid earth ground not exceeding 5 ohms.

3.2.1 Grounding Electrodes

Provide driven ground rods as specified in Section 16402 INTERIOR DISTRIBUTION SYSTEM. Connect ground conductors to the upper end of the ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.2.2 Substation Grounding

Surge arrester and neutrals shall be bonded directly to the transformer enclosure and then to the grounding electrode system with bare copper conductors, sized as shown. Lead lengths shall be kept as short as practicable with no kinks or sharp bends.

3.2.3 Connections

Make joints in grounding conductors and loops by exothermic weld or compression connector. Exothermic welds and compression connectors shall be installed as specified in Section 16402 INTERIOR DISTRIBUTION SYSTEM, paragraph entitled "Grounding Connections".

3.2.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect unit substations furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.3.1 Interrupter Switchgear

IEEE C37.20.3.

3.3.2 Meters and Instrument Transformers

NEMA C12.1.

3.3.3 Field Applied Painting

Where field applied painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's instructions.

3.3.4 Field Fabricated Nameplate Mounting

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.3.5 Warning Sign Mounting

Provide the number of signs required to be readable from each accessible side, but space the signs a maximum of 30 feet apart.

3.3.6 Galvanizing Repair

Repair damage to galvanized coatings using ASTM A 780, zinc rich paint, for galvanizing damaged by handling, transporting, cutting, welding, or bolting. Do not heat surfaces that repair paint has been applied to.

3.4 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

3.4.1 Interior Location

Mount unit substation on concrete slab. Unless otherwise indicated, the slab shall be at least 6 inches thick. The top of the concrete slab shall be approximately 6 inches above finished floor. Edges above floor shall have 1/2 inch chamfer. The slab shall be of adequate size to project at least 4 inches beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Seals shall be of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter. Cut off and bush conduits 3 inches above slab surface.

3.4.2 Cast-in-Place Concrete

Cast-in-place concrete work shall conform to the requirements of Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE.

3.5 FIELD QUALITY CONTROL

3.5.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.5.1.1 Interrupter Switchgear (Air Switches)

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Confirm correct application of manufacturer's recommended lubricants.

4. Verify appropriate anchorage and required area clearances.

5. Verify appropriate equipment grounding.

6. Verify correct blade alignment, blade penetration, travel stops, and mechanical operation.

7. Verify that fuse sizes and types correspond to approved shop drawings.

8. Verify that each fuse holder has adequate mechanical support.

9. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method,

or performing thermographic survey.

10. Test interlocking systems for correct operation and sequencing.

11. Verify correct phase barrier materials and installation.

12. Compare switch blade clearances with industry standards.

13. Inspect all indicating devices for correct operation

b. Electrical Tests

1. Perform insulation-resistance tests.

2. Perform over-potential tests.

4. Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

5. Measure closed contact-resistance across each switch blade and fuse holder.

6. Measure fuse resistance.

7. Verify heater operation.

3.5.1.2 Transformers - (Dry-Type)

a. Visual and Mechanical Inspection

1. Compare equipment nameplate information with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Verify that control and alarm settings on temperature indicators are as specified.

4. Verify that cooling fans operate correctly and that fan motors have correct overcurrent protection.

5. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

6. Perform specific inspections and mechanical tests as recommended by manufacturer.

7. Verify that resilient mounts are free and shipping brackets have been removed.

8. Verify that winding core, frame, and enclosure groundings are correct.

9. Verify the presence of transformer surge arresters.

10. Verify that as-left tap connections are as specified.

b. Electrical Tests

1. Perform insulation-resistance tests.

2. Perform power-factor tests or dissipation-factor tests in accordance with the test equipment manufacturer's instructions.

3. Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

4. Perform turns-ratio tests.

5. Perform overpotential test on all high- and low-voltage windings-to-ground.

6. Verify correct secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.

2.5.1.3 Current Transformers

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Verify correct connection.

4. Verify that adequate clearances exist between primary and secondary circuit.

5. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

6. Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests

1. Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

2. Perform insulation-resistance tests.

3. Perform polarity tests.

4. Perform ratio-verification tests.

3.5.1.4 Metering and Instrumentation

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Verify tightness of electrical connections.

b. Electrical Tests

1. Verify accuracy of meters at 25, 50, 75, and 100 percent of full scale.

2. Calibrate watthour meters according to manufacturer's published data.

3. Verify all instrument multipliers.

4. Verify that current transformer and voltage transformer secondary circuits are intact.

3.5.1.5 Grounding System

a. Visual and Mechanical Inspection

1. Inspect ground system for compliance with contract plans and specifications.

3.5.2 Protective Relays

Protective relays shall be visually and mechanically inspected, adjusted, tested, and calibrated in accordance with the manufacturer's published instructions. Tests shall include pick-up, timing, contact action, restraint, and other aspects necessary to ensure proper calibration and operation. Relay settings shall be implemented as directed by the Contracting Officer. Relay contacts shall be manually or electrically operated to verify that the proper breakers and alarms initiate. Relaying current transformers shall be field tested in accordance with IEEE C57.13.

3.5.3 Pre-Energization Services

Calibration, testing, adjustment, and placing into service of the installation shall be accomplished by a manufacturer's product field service engineer or independent testing company with a minimum of 2 years of current product experience. The following services shall be performed subsequent to testing but prior to the initial energization. The equipment shall be inspected to ensure that installation is in compliance with the recommendations of the manufacturer and as shown on the detail drawings. Terminations of conductors at major equipment shall be inspected to ensure the adequacy of connections. Bare and insulated conductors between such terminations shall be inspected to detect possible damage during installation. If factory tests were not performed on completed assemblies, tests shall be performed after the installation of completed assemblies. Components shall be inspected for damage caused during installation or shipment to ensure packaging materials have been removed. Components capable of being both manually and electrically operated shall be operated manually prior to the first electrical operation. Components capable of being calibrated, adjusted, and tested shall be calibrated, adjusted, and tested in accordance with the instructions of the equipment manufacturer.

3.5.4 Follow-Up Verification

Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Test shall require each item to perform its function not less than three times. As an exception to requirements stated elsewhere in the contract, the Contracting Officer shall be given 5 working days' advance notice of the dates and times for checks, settings, and tests.

-- End of Section –

SECTION 16402
INTERIOR DISTRIBUTION SYSTEM
04/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C80.5	(1994) Aluminum Rigid Conduit (ARC)

ASTM INTERNATIONAL (ASTM)

ASTM B 1	(2001) Hard-Drawn Copper Wire
ASTM B 8	(2004) Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM D 709	(2001) Laminated Thermosetting Materials

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

EIA TIA/EIA-568-B.1	(2001; Addendum 2001) Commercial Building Telecommunications Cabling Standard - Part 1: General Requirements (ANSI/TIA/EIA-568-B.1)
EIA TIA/EIA-569-A	(1998; Addenda 2000, 2001) Commercial Building Standards for Telecommunications Pathways and Spaces (ANSI/TIA/EIA-569-A)
TIA J-STD-607-A	(2002) Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2005) National Electrical Safety Code
IEEE Std 100	(2000) The Authoritave Dictionary of IEEE Standards Terms
IEEE Std 81	(1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (Part 1)Normal Measurements

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2003) Acceptance Testing Specifications

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2003) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA C80.1	(1994) Rigid Steel Conduit - Zinc Coated (GRC)
NEMA C80.3	(1994) Electrical Metallic Tubing - Zinc Coated (EMT)
NEMA FU 1	(2002) Low Voltage Cartridge Fuses
NEMA ICS 1	(2000; R 2005) Industrial Control and Systems: General Requirements
NEMA ICS 2	(1996; R 2004) Standard for Industrial Control and Systems: Controllers, Contractors, and Overload Relays Rated Not More than 2000 Volts AC or 750 Volts DC: Part 8 - Disconnect Devices for Use in Industrial Control Equipment
NEMA ICS 3	(2005) Industrial Control and Systems: Medium Voltage Controllers Rated 2001 to 7200 Volts AC
NEMA ICS 4	(2000) Industrial Control and Systems: Terminal Blocks
NEMA ICS 6	(1993; R 2001) Industrial Control and Systems: Enclosures
NEMA KS 1	(2001) Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
NEMA MG 1	(2003; R 2004) Motors and Generators
NEMA MG 10	(2001) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors
NEMA MG 11	(1977; R 1997; R 2001) Energy Management Guide for Selection and Use of Single Phase Motors
NEMA ST 20	(1992; R 1997) Dry-Type Transformers for General Applications
NEMA TC 2	(2003) Electrical Polyvinyl Chloride (PVC) Tubing and Conduit
NEMA TC 3	(2004) Polyvinyl Chloride PVC Fittings for Use with Rigid PVC Conduit and Tubing
NEMA TP 1	(2002) Guide for Determining Energy Efficiency for Distribution Transformers

NEMA VE 1	(2002) Metal Cable Tray Systems
NEMA WD 1	(1999) General Color Requirements for Wiring Devices
NEMA WD 6	(2002) Wiring Devices - Dimensional Requirements
NEMA Z535.4	(2002) Product Safety Signs and Labels

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2005) National Electrical Code
NFPA 70E	(2004) Electrical Safety in the Workplace
NFPA 780	(2004) Installation of Lightning Protection Systems

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.147	Control of Hazardous Energy (Lock Out/Tag Out)

UNDERWRITERS LABORATORIES (UL)

UL 1	(2005) Flexible Metal Conduit
UL 1010	(1995; Rev thru Mar 1999) Receptacle-Plug Combinations for Use in Hazardous (Classified) Locations
UL 1063	(1998; Rev thru Jun 2001) Machine-Tools Wires and Cables
UL 1242	(2000; Rev thru May 2003) Electrical Intermediate Metal Conduit – Steel
UL 1449	(1996; Rev thru Jul 2002) Transient Voltage Surge Suppressors
UL 1561	(1999; Rev thru Feb 2004) Dry-Type General Purpose and Power Transformers
UL 1569	(1999; Rev thru Mar 2004) Metal-Clad Cables
UL 1660	(2004) Liquid-Tight Flexible Nonmetallic Conduit
UL 20	(2000; Rev thru Jun 2002) General-Use Snap Switches
UL 360	(2003) Liquid-Tight Flexible Steel Conduits
UL 4	(2004) Armored Cable
UL 44	(2005) Thermoset-Insulated Wires and Cables

UL 467	(2004) Grounding and Bonding Equipment
UL 486A-486B	(2003; Rev thru Apr 2004) Wire Connectors
UL 489	(2002; Rev thru May 2003) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
UL 498	(2001; Rev thru Oct 2002) Attachment Plugs and Receptacles
UL 5	(2004) Surface Metal Raceways and Fittings
UL 50	(1995; Rev thru Sep 2003) Enclosures for Electrical Equipment
UL 506	(2000; Rev thru Feb 2004) Specialty Transformers
UL 508	(1999; Rev thru Dec 2003) Industrial Control Equipment
UL 510	(2005) Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape
UL 512	(1993; Rev thru Mar 1999) Fuseholders
UL 514A	(2004) Metallic Outlet Boxes
UL 514B	(2004) Conduit, Tubing and Cable Fittings
UL 514C	(1996; Rev thru Nov 2002) Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 6	(2000; Rev thru May 2003) Rigid Metal Conduit
UL 651	(2005) Schedule 40 and 80 Rigid PVC Conduit
UL 67	(1993; Rev thru Nov 2003) Panelboards
UL 674	(2003) Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations
UL 698	(1995; Rev thru Mar 1999) Industrial Control Equipment for Hazardous (Classified) Locations
UL 6A	(2000; Rev thru Jan 2004) Electrical Rigid Metal Conduit - Aluminum, Bronze, and Stainless Steel
UL 797	(2004) Electrical Metallic Tubing – Steel
UL 83	(2003; Rev thru Mar 2004) Thermoplastic-Insulated Wires and Cables

UL 845	(2005) Motor Control Centers
UL 869A	(1998) Reference Standard for Service Equipment
UL 870	(1995; Rev thru Jul 2003) Wireways, Auxiliary Gutters, and Associated Fittings
UL 877	(1993; Rev thru Nov 1999) Circuit Breakers and Circuit-Breaker Enclosures for Use in Hazardous (Classified) Locations
UL 886	(1994; Rev thru Apr 1999) Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations
UL 943	(2006) Ground-Fault Circuit-Interrupters
UL 984	(1996) Hermetic Refrigerant Motor-Compressors

1.2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE Std 100.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Panelboards; G

Transformers; G

Cable trays; G

Motor control centers; G

Power Distribution Units (PDU); G

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices.

Wireways; G

Marking strips drawings; G

SD-03 Product Data

Receptacles; G

Circuit breakers; G

Switches; G

Transformers; G

Power Distribution Units (PDU); G

Enclosed circuit breakers; G

Motor controllers; G

Combination motor controllers; G

Manual motor starters; G

Telecommunications Grounding Busbar; G

Surge protective devices; G

Submittals shall include performance and characteristic curves.

SD-06 Test Reports

600-volt wiring test; G

Grounding system test; G

Transformer tests; G

Power Distribution Units (PDU); G

Ground-fault receptacle test; G

SD-07 Certificates

Fuses; G

SD-09 Manufacturer's Field Reports

Transformer factory tests

SD-10 Operation and Maintenance Data

Electrical Systems, Data Package 5; G

Submit operation and maintenance data in accordance with Section 01781 OPERATION AND MAINTENANCE DATA and as specified herein.

1.4 QUALITY ASSURANCE

1.4.1 Fuses

Submit coordination data as specified in paragraph, FUSES of this section.

1.4.2 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.4.3 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section. All electrical products shall be installed according to the manufactures instructions.

1.4.3.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.4.3.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.5 MAINTENANCE

1.5.1 Electrical Systems

Submit operation and maintenance manuals for electrical systems that provide basic data relating to the design, operation, and maintenance of the electrical distribution system for the building. This shall include:

a. Single line diagram of the "as-built" building electrical system.

b. Schematic diagram of electrical control system (other than HVAC, covered elsewhere).

c. Manufacturers' operating and maintenance manuals on active electrical equipment.

1.6 WARRANTY

The equipment items shall be supported by service organizations which are

reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.7 SEISMIC REQUIREMENTS

Seismic details shall conform to Section 13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and to Section 16070, SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Materials, equipment, and devices shall, as a minimum, meet requirements of UL, where UL standards are established for those items, and requirements of NFPA 70.

2.2 CONDUIT AND FITTINGS

Shall conform to the following:

2.2.1 Rigid Metallic Conduit

2.2.1.1 Rigid, Threaded Zinc-Coated Steel Conduit
NEMA C80.1, UL 6.

2.2.1.2 Rigid Aluminum Conduit
ANSI C80.5, UL 6A.

2.2.2 Rigid Nonmetallic Conduit
PVC Type EPC-40, and EPC-80 in accordance with NEMA TC 2,UL 651.

2.2.3 Intermediate Metal Conduit (IMC)

UL 1242, zinc-coated steel only.

2.2.4 Electrical, Zinc-Coated Steel Metallic Tubing (EMT)

UL 797, NEMA C80.3.

2.2.5 Flexible Metal Conduit

UL 1.

2.2.5.1 Liquid-Tight Flexible Metal Conduit, Steel

UL 360.

2.2.6 Fittings for Metal Conduit, EMT, and Flexible Metal Conduit

UL 514B. Ferrous fittings shall be cadmium- or zinc-coated in accordance with UL 514B.

2.2.6.1 Fittings for Rigid Metal Conduit and IMC

Threaded-type. Split couplings unacceptable.

2.2.6.2 Fittings for EMT

steel compression type.

2.2.7 Fittings for Rigid Nonmetallic Conduit

NEMA TC 3 for PVC, and UL 514B.

2.2.8 Liquid-Tight Flexible Nonmetallic Conduit

UL 1660.

2.3 SURFACE RACEWAY

2.3.1 Surface Metal Raceway

UL 5, two-piece painted steel, totally enclosed, snap-cover type. Provide multiple outlet-type raceway with grounding-type receptacle where indicated. Receptacles shall be as specified herein and shall be spaced, as indicated.

2.4 CABLE TRAYS

NEMA VE 1. Cable trays shall form a wireway system, and shall be, as indicated. Cable trays shall be constructed of steel that has been zinc-coated after fabrication. Trays shall include splice and end plates, dropouts, and miscellaneous hardware. Edges, fittings, and hardware shall be finished free from burrs and sharp edges. Fittings shall have not less than load-carrying ability of straight tray sections and shall have manufacturer's minimum standard radius. Radius of bends shall be 12 inches.

2.4.1 Basket-Type Cable Trays

Provide size as indicated with maximum wire mesh spacing of 2 by 4 inch.

2.4.2 Trough-Type Cable Trays

Provide size as indicated.

2.4.3 Ladder-Type Cable Trays

Provide size as indicated with maximum rung spacing of 12 inches.

2.5 OUTLET BOXES AND COVERS

UL 514A, cadmium- or zinc-coated, if ferrous metal. UL 514C, if nonmetallic.

2.5.1 Floor Outlet Boxes

Boxes shall be adjustable and concrete tight. Each outlet shall consist of nonmetallic or cast-metal body with threaded openings, or sheet-steel body with knockouts for conduits, adjustable, brass flange ring, and cover plate with 3/4 inch threaded plug. Telecommunications outlets shall consist of surface-mounted, horizontal flush, aluminum or stainless steel housing with a receptacle as specified and one inch bushed side opening 3/4 inch top opening. Receptacle outlets shall consist of 0surface-mounted, horizontal flush aluminum or stainless steel housing with duplex-type receptacle as specified herein. Provide gaskets where necessary to ensure watertight installation. Provide plugs with installation instructions to the Contracting Officer for 5 percent of outlet boxes for the capping of outlets upon removal of service fittings.

2.5.2 Outlet Boxes for Telecommunications System

Provide standard type 4 inches square by 2 1/8 inches deep. Depth of boxes shall be large enough to allow manufacturers' recommended conductor bend radii. Outlet boxes for fiber optic telecommunication outlets shall include a minimum 3/8 inch deep single or two gang plaster ring as shown and installed using a minimum 1 inch conduit stubbed above ceiling to cable tray or wireway or below access floor and terminated with insulated bushing.

2.6 CABINETS, JUNCTION BOXES, AND PULL BOXES

Volume greater than 100 cubic inches, UL 50, hot-dip, zinc-coated, if sheet steel. All boxes greater than 400 cubic inches and/or having an opening greater than 64 square inches shall have hinged covers.

2.7 WIRES AND CABLES

Wires and cables shall meet applicable requirements of NFPA 70 and UL for type of insulation, jacket, and conductor specified or indicated. Wires and cables manufactured more than 12 months prior to date of delivery to site shall not be used. UL listed type MC cable may be used in applications approved by NFPA 70, (NEC). All wiring methods used in underfloor applications must be acceptable for use in areas handling environmental air, whether or not environment air is used in the underfloor area or not. Article 300.22 (B) shall apply in all of these areas.

2.7.1 Conductors

Conductors No. 8 AWG and larger diameter shall be stranded. Conductors No. 10 AWG and smaller diameter shall be solid, except that conductors for remote control, alarm, and signal circuits, classes 1, 2, and 3, shall be stranded unless specifically indicated otherwise. Conductor sizes and ampacities shown are based on copper, unless indicated otherwise. All conductors shall be copper. The minimum branch circuit serving underfloor devices shall be number 10 AWG.

2.7.1.1 Minimum Conductor Sizes

Minimum size for branch circuits shall be No. 12 AWG; for Class 1 remote-control and signal circuits, No. 14 AWG; for Class 2 low-energy, remote-control and signal circuits, No. 14 AWG; and for Class 3 low-energy, remote-control, alarm and signal circuits, No. 22 AWG.

2.7.2 Color Coding

Provide for service, feeder, branch, control, and signaling circuit conductors. Color shall be green for grounding conductors and white for neutrals; except where neutrals of more than one system are installed in same raceway or box, other neutrals shall be white with a different colored (not green) stripe for each. Color of ungrounded conductors in different voltage systems shall be as follows:

a. 208/120 volt, three-phase

(1) Phase A - black
(2) Phase B - red
(3) Phase C – blue

b. 480/277 volt, three-phase

(1) Phase A - brown
(2) Phase B - orange
(3) Phase C – yellow

c. 120/240 volt, single phase: Black and red

2.7.3 Insulation

Unless specified or indicated otherwise or required by NFPA 70, power and lighting wires shall be 600-volt, Type THWN conforming to UL 83. Remote-control and signal circuits shall be Type TW or TF, conforming to UL 83. Where lighting fixtures require 90-degree Centigrade (C) conductors, provide only conductors with 90-degree C insulation or better.

2.7.4 Bonding Conductors

ASTM B 1, solid bare copper wire for sizes No. 8 AWG and smaller diameter; ASTM B 8, Class B, stranded bare copper wire for sizes No. 6 AWG and larger diameter.

2.7.4.1 Telecommunications Bonding Backbone (TBB)

Provide a copper conductor TBB in accordance with TIA J-STD-607-A. The TBB shall be a minimum No. 6 AWG and be sized at 2 kcmil per linear foot of conductor length up to a maximum size of 3/0 AWG. Provide insulated TBB with insulation as specified in the paragraph INSULATION and meeting the fire ratings of its pathway.

2.7.4.2 Bonding Conductor for Telecommunications
Provide a copper conductor Bonding Conductor for Telecommunications between the telecommunications main grounding busbar (TMGB) and the electrical service ground in accordance with TIA J-STD-607-A. The bonding conductor for telecommunications shall be sized the same as the TBB.

2.7.5 Metal-Clad Cable

UL 1569; NFPA 70, Type MC cable.

2.7.6 Fire Rated MC cable

UL 4; NFPA 70, 2-hour fire-rated MC cable with polymeric (silicone rubber) insulation , rated for 600 Volt applications with a temperature rating of 90 degrees C dry, and be wet location approved. The complete cable system shall have a 2-hour rating as listed and classified by Underwriters Laboratories, Inc.

2.7.7 Mineral-Insulated, Metal-Sheathed Cable

UL listed; NFPA 70, Type MI cable. Sheathing containing asbestos fibers shall not be used.

2.8 SPLICES AND TERMINATION COMPONENTS

UL 486A-486B for wire connectors and UL 510 for insulating tapes. Connectors for No. 10 AWG and smaller diameter wires shall be insulated, pressure-type in accordance with UL 486A-486B. Provide solderless terminal lugs on stranded conductors.

2.9 DEVICE PLATES

Provide UL listed, one-piece device plates for outlets to suit the devices installed. For metal outlet boxes, plates on unfinished walls shall be of zinc-coated sheet steel or cast metal having round or beveled edges. For nonmetallic boxes and fittings, other suitable plates may be provided. Plates on finished walls shall be satin finish stainless steel or brushed-finish aluminum, minimum 0.03 inch thick. Screws shall be machine-type with countersunk heads in color to match finish of plate. Sectional type device plates will not be permitted. Plates installed in wet locations shall be gasketed and UL listed for "wet locations."

2.10 SWITCHES

2.10.1 Toggle Switches

NEMA WD 1, UL 20, single pole, double pole, three-way, and four-way, totally enclosed with bodies of thermoplastic or thermoset plastic and mounting strap with grounding screw. Handles shall be ivory thermoplastic. Wiring terminals shall be screw-type, side-wired. Contacts shall be silver-cadmium and contact arm shall be one-piece copper alloy. Switches shall be rated quiet-type ac only, 120/277 volts, with current rating and number of poles indicated.

2.10.2 Switch with Red Pilot Handle

NEMA WD 1. Provide pilot lights that are integrally constructed as a part of the switch's handle. The pilot light shall be red and shall illuminate whenever the switch is closed or "on". The pilot lighted switch shall be rated 20 amps and 120 volts or 277 volts as indicated. Provide the circuit's neutral conductor to each switch with a pilot light.

2.10.3 Disconnect Switches

NEMA KS 1. Provide heavy duty-type switches where indicated, where switches are rated higher than 240 volts, and for double-throw switches. Fused switches shall utilize Class R fuseholders and fuses, unless indicated otherwise. Switches serving as motor-disconnect means shall be horsepower rated. Provide switches as indicated per NEMA ICS 6.

2.11 FUSES

NEMA FU 1. Provide complete set of fuses for each fusible panel and motor control center. Time-current characteristics curves of fuses serving motors or connected in series with circuit breakers shall be coordinated for proper operation. Submit coordination data for approval. Fuses shall

have voltage rating not less than circuit voltage.
2.11.1 Cartridge Fuses

2.11.1.1 Characteristics

NEMA FU 1 nonrenewable cartridge fuse, class as specified or indicated, current rating as indicated, voltage rating consistent with circuit voltage.

2.11.1.2 Cartridge Fuses

Cartridge fuses shall be as described below and shall have a minimum interrupting rating of 200,000 symmetrical amperes for the AC voltage at which they are rated.

a. Fused rated 601 amperes through 6,000 amperes: Provide UL class L fuses.

b. Fuses Rated 600 Amperes and Less: Unless specifically shown otherwise on the drawings, provide the following classes of fuses:

1. Motor branch circuit fuses, where the fuse is the final overcurrent device in the circuit: UL class time delay fuses. Need RK-1 fuses to provide Type 2 (no damage) protection to motor starters and contacts.

2. Feeder fuses, such as for panelboards, where the fuse supplies a downstream circuit breaker or other UL Class RK-5 fuse: UL Class RK-5 dual element time delay fuses.

3. Emegency Lighting Branch Circuit Fuses: UL Class CC, Bussmann KTK or Ferraz Shawmut ATQR.

4. Feeder fuses where the fuse supplies only another UL Class RK-1 fuse: UL Class RK-1 dual element time-delay fuses.

2.11.1.3 Control Circuit Fuses

Provide Bussmann Type KTK-R or Ferraz Shawmutt, rejection type, Class CC current limiting fuses for control circuit protection.

2.11.2 Fuseholders

Provide in accordance with UL 512.

2.12 RECEPTACLES

UL 498, hard use, heavy-duty, grounding-type. Ratings and configurations shall be as indicated. Bodies shall be of ivory as per NEMA WD 1. Face and body shall be thermoplastic supported on a metal mounting strap. Dimensional requirements shall be per NEMA WD 6. Provide screw-type, side-wired wiring terminals. Connect grounding pole to mounting strap. The receptacle shall contain triple-wipe power contacts and double or triple-wipe ground contacts.

2.12.1 Switched Duplex Receptacles

Provide separate terminals for each ungrounded pole. Top receptacle shall be switched when installed.

2.12.2 Weatherproof Receptacles

Provide in cast metal box with gasketed, weatherproof, cast-metal cover plate and gasketed cap over each receptacle opening. Provide caps with a spring-hinged flap. Receptacle shall be UL listed for use in "wet locations with plug in use."

2.12.3 Ground-Fault Circuit Interrupter Receptacles

UL 943, duplex type for mounting in standard outlet box. Device shall be capable of detecting current leak of 6 milliamperes or greater and tripping per requirements of UL 943 for Class A GFCI devices. Provide screw-type, side-wired wiring terminals or pre-wired (pigtail) leads.

2.12.4 Special Purpose Receptacles

Provide in ratings and NEMA configuration as indicated. Furnish one matching plug with each receptacle.

2.12.5 Plugs

Provide heavy-duty, rubber-covered three-, four-, or five-wire cord of required size, install plugs thereon, and attach to equipment. Plugs shall be UL listed with receptacles, complete with grounding blades. Where equipment is not available, turn over plugs and cord assemblies to the Government.

2.13 PANELBOARDS

UL 67 and UL 50 having a short-circuit current rating as indicated or of 10,000 amperes symmetrical minimum. Panelboards for use as service disconnecting means shall additionally conform to UL 869A. Panelboards shall be circuit breaker-equipped. Design shall be such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining clearances as required by UL. "Specific breaker placement" is required in panelboards to match the breaker placement indicated in the panelboard schedule on the drawings. Use of "Subfeed Breakers" is not acceptable unless specifically indicated otherwise. Main breaker shall be "separately" mounted "above" or "below" branch breakers. Where "space only" is indicated, make provisions for future installation of breakers. Directories shall indicate load served by each circuit in panelboard. Directories shall also indicate source of service to panelboard (e.g., Panel PA served from panel. Type directories and mount in holder behind transparent protective covering. Panelboards shall be listed and labeled for their intended use. Panelboard shall have engraved laminated acrylic or melamine plastic nameplates in accordance with paragraph FIELD FABRICATED NAMEPLATES.

2.13.1 Enclosure

Enclosures shall meet the requirements of UL 50. All cabinets shall be fabricated from sheet steel of not less than No. 10 gauge if flush-mounted or mounted outdoors, and not less than No. 12 gauge if surface-mounted indoors, with full seam-welded box ends. Provide metal nameplate containing system information, catalog number and factory order number. Nameplate shall be secured to the dead-front with rivets or screws. Interior wiring diagram, neutral wiring diagram, UL listing number and short circuit current rating labels shall be permanently affixed to the interior. Cabinets mounted outdoors or flush-mounted shall be hot-dipped galvanized after fabrication. Cabinets shall be painted in accordance with paragraph PAINTING. Outdoor cabinets shall be of NEMA 3R raintight with conduit hubs welded to the cabinet. Front edges of cabinets shall be form-flanged or fitted with structural shapes welded or riveted to the sheet steel, for supporting the panelboard front. All cabinets shall be so fabricated that no part of any surface on the finished cabinet shall deviate from a true plane by more than 1/8 inch. Holes shall be provided in the back of indoor surface-mounted cabinets, with outside spacers and inside stiffeners, for mounting the cabinets with a 1/2 inch clear space between the back of the cabinet and the wall surface. Flush doors shall be mounted on hinges that expose only the hinge roll to view when the door is closed. Each door shall be fitted with a combined catch and lock, except that doors over 24 inches long shall be provided with a three-point latch having a knob with a T-handle, and a cylinder lock. Two keys shall be provided with each lock, and all locks shall be keyed alike. Finished-head cap screws shall be provided for mounting the panelboard fronts on the cabinets.

2.13.2 Doors

a. In panelboard front, with concealed hinges. Secure with flush catch and tumbler lock, all keyed alike. Label panelboards with identification shown on drawings.Panelboards shall have dead front cabinets, flush or surface mounted as indicted. Distribution panelboard trims shall cover all live parts. Doors in panelboard trims shall not uncover any live parts. Switching device handles shall be accessible.
Panel boards shall also have the following labeling:

1. Lighting panels shall be labeled "For Lighting Circuits ONLY"
2. Life safety panels shall be labeled "For Life Safety Circuits ONLY"
3. UPS panel shall be labeled "For Critical/UPS Circuits ONLY"

b. UL 67 and UL 50 having a short-circuit current rating as indicated. Panelboards for use as service disconnecting means shall additionally conform to UL 869A. Panelboards shall be circuit breaker-equipped unless indicated otherwise. Design shall be such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining clearances as required by UL. "Specific breaker placement" is required in panelboards to match the breaker placement indicated in the panelboard schedule on the drawings. Use of "Subfeed Breakers" is not acceptable unless specifically indicated otherwise. Main breaker shall be "separately" mounted "above" or "below" branch breakers. Where "space only" is indicated, make provisions for future installation of breakers. Directories shall indicate load served by each circuit in panelboard. Directories shall also indicate source of service to panelboard (e.g., Panel PA served from Panel MDP). Provide new directories for existing panels modified by this project as indicated. Type directories and mount in a metal directory frame with a transparent mounted inside each panelboard door. Panelboards shall be listed and labeled for their intended use. Panelboard shall have nameplates in accordance with Paragraph FIELD FABRICATED NAMEPLATES.

c. All panelboards shall be fully rated. Series rated panelboards are not acceptable. All panelboards shall be 42 pole minimum or 63 inches

of breaker mounting space for distribution type panelboards.

2.13.3 Panelboard Buses

The main and neutral busses shall be hard drawn copper of 98 percent conductivity. Horizontal bussing shall be fully rated, non-tapered, extended, drilled and tapped for extension to future sections without modifying the bus. Support bus bars on bases independent of circuit breakers. Main buses and back pans shall be designed so that breakers may be changed without machining, drilling, or tapping. Provide isolated neutral bus in each panel for connection of circuit neutral conductors. Provide separate ground bus identified as equipment grounding bus per UL 67 for connecting grounding conductors; bond to steel cabinet.

2.13.3.1 Panelboard Neutrals for Non-Linear Loads

2.15.2.1.1 Neutral Bus

Panelboard for non-linear loads shall have 200% rated neutral buses constructed of hard drawn copper of 98% conductivity.

2.15.2.1.2 Heat Rise Test

UL listed, and panelboard type shall have been specifically UL heat rise tested for use on non-linear loads. The equipment ground bus shall be adequate for panelboard feeder and branch-circuit equipment ground conductors. Equipment ground bus shall be large enough and have sufficient quantity and sizes of terminations to allow for termination of panelboard feeder plus one equipment grounding conductor per circuit, based on the maximum number of branch circuit protective devices allowed in the panelboard plus 6 additional conductors. Increase terminations to accommodate additional feeder conductors where double lugged panelboards are indicated.

When panelboards consist of multiple sections, provide equipment ground busses in each section of sufficient size for all grounding conductors in that section. Ground busses to be insulated from the panelboard enclosure where isolated ground busses are called for; ground busses shall be bonded to enclosure when isolated ground buses are not specified. Ground bus to be rated minimum 12-1/2 per cent of the main bus rating. Panelboard shall be heat rise tested in accordance with UL 67, except with the neutral assembly installed and carrying 200 percent of the phase bus current during testing. Verification of the testing procedure shall be provided upon request. Two neutral assemblies paralleled together with cable is not acceptable. Nameplates for panelboard rated for use on non-linear loads shall be marked "SUITABLE FOR NON-LINEAR LOADS"and shall be in accordance with paragraph FIELD FABRICATED NAMEPLATES. Provide a neutral label with instructions for wiring the neutral of panelboards rated for use on non-linear loads.

2.13.4 Circuit Breakers

UL 489, thermal magnetic-type having a minimum short-circuit current rating equal to the short-circuit current rating of the panelboard in which the circuit breaker shall be mounted. Breaker terminals shall be UL listed as suitable for type of conductor provided. Where indicated on the drawings, provide circuit breakers with shunt trip devices. Series rated circuit

breakers and plug-in circuit breakers are unacceptable.

2.13.4.1 Multipole Breakers

Provide common trip-type with single operating handle. Breaker design shall be such that overload in one pole automatically causes all poles to open. Maintain phase sequence throughout each panel so that any three adjacent breaker poles are connected to Phases A, B, and C, respectively.

2.13.4.2 Circuit Breaker With GFI

UL 943 and NFPA 70. Provide with "push-to-test" button, visible indication of tripped condition, and ability to detect and trip on current imbalance of 6 milliamperes or greater per requirements of UL 943 for Class AGFI devices, for personnel protection, and 20 milliamperes or greater per requirements of UL 943 for Class B GFI per equipment protection.

2.13.4.3 Circuit Breakers for HVAC Equipment

Circuit breakers for HVAC equipment having motors (group or individual) shall be marked for use with HACR type and UL listed as HACR type.

2.14 REMOTE POWER PANELS (at Data Equipment Racks)

Provide at Data Racks as indicated on the drawings. Branch circuiting downstream of the RPP will be performed by others under separate requirements.

2.14.1 Frame Construction and Enclosure

a. The cabinet shall be a freestanding NEMA Type 1 enclosure and meet IP20 requirements. The unit shall have lockable, removable, hinged doors. The unit shall have easily removable and interchangeable output cable trays to allow matching of the size and number of cable and conduit openings to the site requirements. A minimum of 168 cable and conduit openings shall be provided. All service shall be capable of being performed with access to the front and rear, plus one side for installation flexibility. A tool shall be required to remove the exterior panels that access the hazardous voltage area of the unit. Hinged doors shall provide access to the main panelboard circuit breakers and to all output circuit breakers. The color of the exterior doors and panels shall be manufacturer's standard color.

b. The unit shall be naturally convection-cooled. No fans for forced-air cooling system shall be used. The convection cooling method shall allow continuous full-load operation. Heat rejection shall be through a screened protective top that prohibits entry of foreign material.

c. The cabinet dimensions shall be a maximum of 24 inches wide by 78 inches high by 26 inches deep. The distributed floor weight shall be less than 250 lbs/square foot. All panelboards and switchboards shall be provided with a readily available Lock-out/Tag-out system. The system shall provide the operator with all the equipment necessary to Lock-out/Tag-out at the panelboard or switchboard except for a standard lock. The system shall be Power Bloc or approved equivalent.

2.14.2 Input Power Connections

Input power conductors shall connect to the main panelboard circuit breakers or terminal blocks. Power terminals shall be provided for

connection of a 173 percent rated neutral, and a parity-sized insulated ground. A Main Input Junction Box with individually power terminal blocks shall be provided for connection of the input power conductors, 173 percent rated neutral, and a parity-sized insulated ground.

2.14.3 Panelboard Main Circuit Breaker

Each distribution panelboard shall be protected by a main panelboard circuit breaker. The circuit breaker shall be UL listed for use at the system voltage.

2.14.4 Distribution Panelboaards

The specified system shall contain four vertically mounted panelboard(s) for distribution to the intended loads. Two 42-circuit panelboards shall be accessed from the front of the unit and two 42-circuit panelboards shall be accessed from the rear of the unit. Each panelboard shall be totally enclosed with a hinged accent panel that provides access to that panelboard without exposing other portions of the unit. The hinged accent panel shall include mechanical adjustments to allow for proper fit over the branch breakers. The panelboard shall have a rating of 225 amperes, with an overall short-circuit current rating of 22,000 RMS symmetrical amperes. Each panelboard shall include separate isolated neutral and ground bus bars for the neutral and connections for at least 42 output circuits. The neutral bus bar and wiring shall be sized for at least 2.0 times the panelboard full load rating to accommodate high harmonic neutral currents associated with single-phase nonlinear loads.

2.14.4.1 Lock out Tag Out

All panelboards and switchboards shall be provided with a readily available Lock-out/Tag-out system. The system shall provide the operator with all the equipment necessary to Lock-out/Tag-out at the panelboard or switchboard except for a standard lock. The system shall be Power Bloc or approved equivalent.

2.14.4.1.1 Triansient Voltage Surge Suppressor

Transient Voltage Surge Suppressor (TVSS) shall be provided at each branch circuit panelboard feeding computer loads. The TVSS shall be connected on the bus of each panelboard. The lead length shall be minimized to be a short as possible and can not exceed 6" without engineering approval

2.14.5 Branch Circuit Breakers

Each load shall be protected by an individual branch circuit breaker.

2.14.6 Current Monitoring Panel

The current monitoring panel shall consist of a 4 digit high visibility Liquid Crystal Display (LCD) to monitor current parameters. Front and rear LCD's shall be provided with pushbutton switches for operator interface. The three phase and neutral currents for each panelboard shall be displayed. The display and switches shall be accessible without opening the door. All currents shall be monitored using true RMS measurements for accurate representation of non-sinusoidal waveforms typical of computers and other sensitive loads.

2.14.7 View Doors

The enclosure shall be provided with removable, lockable, hinged doors containing a Plexiglas opening that allows the operator to view the branch breakers without opening the door.

2.14.8 Main Circuit Breakers

Main panelboard circuit breakers shall be provided.

2.14.9 Input Junction Box and Cable

An input junction box shall be provided for input power connections and output conduit connections. Power terminal blocks shall be provided for connection of the input power conductors, 173 percent rated neutral, and a parity-sized insulated ground conductor. The junction box shall have maximum dimensions of width, 21 inches; length, 46 inches; height, 15 inches. Junction box will mount below the raised floor under the RPP. Input power cables shall be provided for connection between the RPP and the input junction box. The conductors shall be UL/CSA listed, 90 degrees C minimum insulation, copper conductors, sized in accordance with the NEC. Both for reliability and per the NEC, no plug-and-receptacle connectors shall be used for the input power cables.

2.14.10 Underfloor Conduit Box

An underfloor conduit box shall be provided for input power conduit and output conduit connections. The box shall have an easily removable cable tray on each side. Each tray shall have a minimum of 42 conduit openings and space for an input power cable. The conduit box will mount below the raised floor under the RPP. The conduit box shall have maximum dimensions of width, 24 inches; length, 24 inches; height, 12 inches.

2.15 ENCLOSED CIRCUIT BREAKERS

UL 489. Individual molded case circuit breakers with voltage and continuous current ratings, number of poles, overload trip setting, and short circuit current interrupting rating as indicated. Enclosure type as indicated. Provide solid neutral.

2.16 TRANSFORMERS

NEMA ST 20, general purpose, dry-type, self-cooled, ventilated. Provide transformers in NEMA 1 enclosure. Transformer shall have 220 degrees C insulation system for transformers 15 kVA and greater, and shall have 180 degrees C insulation for transformers rated 10 kVA and less, with temperature rise not exceeding150 degrees C under full-rated load in maximum ambient of 40 degrees C. Transformer of 150 degrees C temperature rise shall be capable of carrying continuously 100 percent of nameplate kVA without exceeding insulation rating. Transformers shall be quiet type with maximum sound level at least 3 decibels less than NEMA standard level for transformer ratings indicated.

2.16.1 Specified Transformer Efficiency

Minimum efficiency, based on factory test results, shall not be less than NEMA Class 1 efficiency as defined by NEMA TP 1.

2.16.2 Transformers With Non-Linear Loads

Transformer insulation shall be a UL recognized 220 degrees C system. Neither the primary nor the secondary temperature shall exceed 220 degrees C at any point in the coils while carrying their full rating of non-sinusoidal load. Transformers are to be UL listed and labeled for K-Factor rating as indicated, K-13 Minimum, in accordance with UL 1561. Transformers evaluated by the UL K-Factor evaluation shall be listed for 115 degrees C average temperature rise only. Transformers with K-Factor ratings with temperature rise of 150 degrees C rise shall not be acceptable. K-Factor rated transformers shall have an impedance range of 3 percent to 5 percent, and shall have a minimum reactance of 2 percent to prevent excessive neutral current when supplying loads with large amounts of third harmonic.

2.17 Power Distribution Units (PDU)

Power Distribution Units (PDU) shall be used for distribution, monitoring and isolation of electrical power for sensitive electronic loads in data center or telecom environments and shall be the primary interface the building's AC power source.

2.17.1 SYSTEM DESCRIPTION

2.17.1.1 Design Requirements

A. The power rating of a PDU shall be as shown on the single line diagrams.

B. Input Characteristics

1. Voltage: 480 VAC, ±15%; 3 phase, 3 wire plus ground; 60 Hz,±5%.

2. Dual or single input as shown on the single line diagram

C. Output Characteristics

1. Voltage: 208 VAC, ±15%, 3 phase, 4 wire plus ground

2. Frequency: 60 Hz, ±5 Hz

3. Load Power Factor: 60% lagging to 60% leading power factor

4. Harmonic Distortion, Voltage: < 1%

5. Efficiency at rated KW load > 96%

2.17.1.2 Components

A. Main Input Circuit Breaker: The PDU shall be equipped with a main input circuit breaker which, when closed and fed by a voltage source, energizes the PDU. The circuit breaker shall provide internal thermal overcurrent and instantaneous short circuit protection. The circuit breaker shall inlcude a 24Vdc shunt trip to automatically open the circuit breaker and disconnect power to the entire unit when the Emergency Power Off (EPO) or remote EPO is activated, or when a designated alarm occurs. The Main input circuit breaker shall be manually operated, automatic trip, rated for 600 VAC, 60 Hz, 3 Phase, and rated not less than 125% of the PDUs full load input current rating. It shall rated to interrupt the maximium available fault current at its location. The main input CB shall be vertically mounted for maximum reliability. The "On" and "Off" positions shall be clearly marked. The CB will provide internal thermal/magnetic overcurrent and instantaneous short circuit protection in each pole. Phase polarities shall be clearly marked.

B. Main Isolation Transformer: The main isolation transformer shall be provided. The output rating of the transformer shall be the same as the continuous duty maximum full load rating of the PDU. The isolation transformer shall be a NEMA ST20, factory-assembled, dry type, double shielded isolation transformer with 200% rated neutral. Each phase of the transformer shall have a three-wire DELTA connected input winding and four-wire WYE connected 208Y/120 VAC output winding. The isolation transformer characteristics shall be:

K-Factor: K-13 @ 115°C rise
Windings: Copper,
Harmonic Distortion: less than 1%
Efficiency: greater than 97%
Insulation system: 220°C, with 150°C winding temperature rise
Impedance: 3% to 4.5% at rated load
Basic impulse level: 10kV

Common mode: -120db,10Hz to 1Mhz
Normal mode: 20db per decade
Ventilation: Convection cooled.
Taps: Compensation taps are provided on the primary windings to allow field adjustment for either low or high source voltages as follows:

FCAN = Full capacity above normal (taps): 2.5%, 5.0%
FCBN = Full capacity below normal (taps): 2.5%, 5.0%, 7.5%, 10%

Temperature Sensors: Two thermal switches shall be wound into each coil "hot spot". At 180 degrees C the first contact closes and causes an LED to illuminate and an audible alarm to turn on at the status panel. At 195 Deg C the second contact closes causing the main input circuit breaker to trip. An LED will illuminate and an audible alarm will turn on at the status panel.

C. Circuit Breakers and Panelboards: Single fed PDU shall be provided with output distribution panelboards, each with the following characteristics and/or features:

1. Branch Circuit Panelboard: NEMA PB1, Square D type Universal (Plug-in or Bolt-on) NQOM442L225CUNLB Panelboard accepting QOB or QOB-VH bolt-on circuit breakers.

Pole Capacity:	42 poles, capable of accepting 1, 2, 3-pole circuit breakers
Bus Rating:	225 Amperes
Copper Ground Bus:	42 terminals
Copper Neutral Bus:	Rated for 200% of nominal phase current.

The panelboard shall accommodate up to 100 Amp CBs and be mounted based on available panelboard cable bending space.

2. Panelboard Main Breaker: Each panelboard shall be protected by a 3 pole main circuit breaker: Rated at 225 Amperes with an Interrupting Capacity: 22,000 AIC.

3. Panelboard Ground Bus: Ground bus located below the panelboard with wire connections for up to 42 wires. Lug range shall be 4 to 12AWG. Ground bus shall be installed for easy access.

D. Sub-Feed Circuit Breakers: Dual Feed PDUs shall be equiped with five sub-feed circuit breakers Rated at 150 Amperes with an Interrupting Capacity: 22,000 AIC.

E. Grounding A main grounding bus bar is provided and is effectively bonded to the unit frame. A ground bus bar is installed in all cabinets. The following points are connected to ground:

a) Isolation transformer neutral
b) Isolation transformer shields and core
c) Primary input cable ground (when provided with jbox)

2.17.2 SYSTEM CONTROLS AND INDICATORS

The PDU shall provide audible and visual alarm indication of abnormal conditions. Upon activation of selected alarms, the PDU sounds an audible alarm and activates an alarm LED. The alarm sounds until an operator presses the "Audible Alarm Silence" button. The reset button silences all existing alarms. Upon activation of the same or a new alarm, the audible alarm will sound again. The audible alarm will be activated only by selected alarm conditions with thresholds factory programmable and stored in non-volatile memory. Factory setting shall be as follows:

Output Overvoltage: +10%
Output Undervoltage: -10%

Transformer Over temperature: Alarm at 180 DEG C: alarm shut down at 195 DEG C Overload (overcurrent):

Single Phase: 110% Phase Loss (output Voltage)
25% of nominal phase-to-neutral or
any phase kVA

2.17.3 Terminations

All primary and secondary power wiring shall be terminated using UL acceptable pressure (crimp) or screw-type lug assemblies. Belleville-type washers and lock washers shall be used on all associated studs or bolt-stacks. Control instrumentation, PC board, and interconnection wiring terminations shall conform to the UL standard. Inductive Noise Coupling: Maximum separation shall be maintained between primary and secondary wiring and / or control/alarm wiring. To the extent possible, no primary or input wiring is permitted to share any area within the PDU that is occupied by secondary wiring except within the main transformer compartment.

2.17.4 Power Wiring

All internal wiring shall be stranded copper with PVC, Neoprene or Silicon insulation with a minimum operating voltage of 600 volts RMS. All wires shall be appropriately marked UL and CSA recognized as being suitable for the application. Minimum insulation temperature rating shall be no less than 105°C, and in no case be less than that required by the location/application of the wiring.

2.17.5 Control Wiring

All control and instrumentation wiring used in this application shall be tinned, stranded copper with a temperature rating of at least 75° C. Insulation type is to be at least 125% of anticipated continuous load (3 hours or longer). Voltage rating is no less than required per UL and NEC. In areas where either primary or secondary AC voltages are present, PC board wiring and interconnect wiring will conform to the requirements of UL

Standard 1950 for the application and location of the wiring.

2.18 MOTORS

NEMA MG 1 except Fire Pump motors shall be as specified in Section 13920 FIRE PUMPS. Hermetic-type sealed motor compressors shall comply with UL 984 in addition to 2.17 requirements. Provide the size in terms of HP, or kVA, or full-load current, or a combination of these characteristics, and other characteristics, of each motor as indicated or specified. Determine specific motor characteristics to ensure provision of correctly sized starters and overload protection. Motors for operation on 208-volt, 3-phase circuits shall have terminal voltage rating of 200 volts, and those for operation on 480-volt, 3-phase circuits shall have terminal voltage rating of 460 volts. Motors shall be designed to operate at full capacity with voltage variation of plus or minus 10 percent of motor voltage rating. Unless otherwise indicated, motors rated 1 HP and above shall be continuous duty type rated for 460V, 3 Phase with a 1.15 service factor. Where fuse protection is specifically recommended by the equipment manufacturer, provide fused switches in lieu of non-fused switches indicated.

2.18.1 High Efficiency Single-Phase Motors

Single-phase fractional-horsepower alternating-current motors shall be high efficiency types corresponding to the applications listed in NEMA MG 11. In exception, for motor-driven equipment with a minimum seasonal or overall efficiency rating, such as a SEER rating, provide equipment with motor to meet the overall system rating indicated.

2.18.2 Premium Efficiency Polyphase Motors

Polyphase motors shall be selected based on high efficiency characteristics relative to typical characteristics and applications as listed in NEMA MG 10. In addition, continuous rated, polyphase squirrel-cage medium induction motors shall meet the requirements for premium efficiency electric motors in accordance with NEMA MG 1, including the NEMA full load efficiency ratings. In exception, for motor-driven equipment with a minimum seasonal or overall efficiency rating, such as a SEER rating, provide equipment with motor to meet the overall system rating indicated.

2.18.3 Motor Sizes

Provide size for duty to be performed, not exceeding the full-load nameplate current rating when driven equipment is operated at specified capacity under most severe conditions likely to be encountered. When motor size provided differs from size indicated or specified, make adjustments to wiring, disconnect devices, and branch circuit protection to accommodate equipment actually provided.

2.18.4 Wiring and Conduit

Provide internal wiring for components of packaged equipment as an integral part of the equipment. Provide power wiring and conduit for field-installed equipment, and motor control equipment forming part of motor control centers or switchgear assemblies, the conduit and wiring

connecting such centers, assemblies, or other power sources to equipment as specified herein. Power wiring and conduit shall conform to the requirements specified herein. Control wiring shall be provided under, and conform to the requirements of the section specifying the associated equipment.

2.19 MOTOR CONTROLLERS

UL 508, NEMA ICS 1, and NEMA ICS 2 except Fire Pump controllers shall be as specified in Section 13920 FIRE PUMPS. Controllers shall be Type 2 (withstand fault conditions without significant damage), have thermal overload protection in each phase and shall have two spare normally open and two spare normally closed auxiliary contact. Provide controllers for motors rated 1-hp and above with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and overvoltage. Magnetic-type motor controllers shall have undervoltage protection when used with momentary-contact pushbutton stations or switches and shall have undervoltage release when used with maintained-contact pushbutton stations or switches. Pushbutton and handswitches shall be heavy duty rated. Each starter cubical shall be equiped with two led indicating lights, one red in color to indicated the motor is running or on. the other shall be green in color and indicate that the motor is not running or off. When used with pressure, float, or similar automatic-type or maintained-contact switch, controller shall have hand/off/automatic selector switch. Connections to selector switch shall be such that only normal automatic regulatory control devices are bypassed when switch is in "hand" position. Safety control devices, such as low and high pressure cutouts, high temperature cutouts, and motor overload protective devices, shall be connected in motor control circuit in "hand" and "automatic" positions. Control circuit connections to hand/off/automatic selector switch or to more than one automatic regulatory control device shall be made in accordance with indicated or manufacturer's approved wiring diagram. For each motor not in sight of controller or where controller disconnecting means is not in sight of motor location and driven machinery location, controller disconnecting means shall be capable of being locked in open position. As an alternative, provide a manually operated, lockable, nonfused switch which disconnects motor from supply source within sight of motor. Overload protective devices shall provide adequate protection to motor windings; be thermal inverse-time-limit type; and include manual reset-type pushbutton on outside of motor controller case. Cover of combination motor controller and manual switch or circuit breaker shall be interlocked with operating handle of switch or circuit breaker so that cover cannot be opened unless handle of switch or circuit breaker is in "off" position. Minimum short circuit withstand rating of combination motor controller shall be 42,000 rms symmetrical amperes. Provide controllers in hazardous locations with classifications as indicated.

2.19.1 Solid-State Overload Relays

Solid State Overload Relay shall be used for to provide Motor overload protection.

a. Provide a solid-state overload relay for protection of the motors. The relay shall be Cutler-Hammer type CEP7 or approved equal.

b. The overload relay shall provide high accuracy through the use of state-of-the-art microelectronic packaging technology. The relay shall be suitable for application with NEMA Size 1 through Size 7 motor starters.

d. The overload relay shall be modular in design, be an integral part of

a family of relays to provide a choice of levels of protection, be designed to directly replace existing electromechanical overload relays, and be listed under UL Standard 508.

e. The overload relay shall have the following features:

1. Be self-powered
2. Class 10 or 20 fixed tripping characteristics
3. Manual or automatic reset
4. Phase loss protection. The relay shall trip in 2 seconds or less under phase loss condition when applied to a fully loaded motor
5. Visible trip indication
6. One NO and one NC isolated auxiliary contact
7. Test button that operates the normally closed contact
8. Test trip function that trips both the NO and NC contacts
9. A current adjustment range of 3.2:1 or greater
10. Ambient temperature compensated
11. Ground fault protection. Relay shall trip at 50% of full load ampere setting
12. Jam/Stall protection. Relay shall trip at 400% of full load ampere setting, after inrush

2.22.1 Control Wiring

All control wire shall be stranded tinned copper switchboard wire with 600-volt flame-retardant insulation Type SIS meeting UL 44, or Type MTW meeting UL 1063, and shall pass the VW-1 flame tests included in those standards. Hinge wire shall have Class K stranding. Current transformer secondary leads shall be not smaller than No. 10 AWG. The minimum size of control wire shall be No. 14 AWG. Power wiring for 480-volt circuits and below shall be of the same type as control wiring and the minimum size shall be No. 12 AWG. Special attention shall be given to wiring and terminal arrangement on the terminal blocks to permit the individual conductors of each external cable to be terminated on adjacent terminal points.

2.19.2 Control Circuit Terminal Blocks

NEMA ICS 4. Control circuit terminal blocks for control wiring shall be molded or fabricated type with barriers, rated not less than 600 volts. The terminals shall be removable binding, fillister or washer head screw type, or of the stud type with contact and locking nuts. The terminals shall be not less than No. 10 in size and shall have sufficient length and space for connecting at least two indented terminals for 10 AWG conductors to each terminal. The terminal arrangement shall be subject to the approval of the Contracting Officer and not less than four (4) spare terminals or 10 percent, whichever is greater, shall be provided on each block or group of blocks. Modular, pull apart, terminal blocks will be acceptable provided they are of the channel or rail-mounted type. The Contractor shall submit data showing that the proposed alternate will accommodate the specified number of wires, are of adequate current-carrying capacity, and are constructed to assure positive contact between current-carrying parts.

2.19.2.1 Types of Terminal Blocks

a. Short-Circuiting Type: Short-circuiting type terminal blocks shall be furnished for all current transformer secondary leads and shall have provision for shorting together all leads from each current transformer without first opening any circuit. Terminal

blocks shall meet the requirements of paragraph CONTROL CIRCUIT TERMINAL BLOCKS above.

b. Load Type: Load terminal blocks rated not less than 600 volts and of adequate capacity shall be provided for the conductors for NEMA Size 3 and smaller motor controllers and for other power circuits, except those for feeder tap units. The terminals shall be of either the stud type with contact nuts and locking nuts or of the removable screw type, having length and space for at least two indented terminals of the size required on the conductors to be terminated. For conductors rated more than 50 amperes, screws shall have hexagonal heads. Conducting parts between connected terminals shall have adequate contact surface and cross-section to operate without overheating. Each connected terminal shall have the circuit designation or wire number placed on or near the terminal in permanent contrasting color.

2.19.3 Control Circuits

Control circuits shall have maximum voltage of 120 volts derived from control transformer in same enclosure and arranged for three wire control. Transformers shall conform to UL 506, as applicable. Transformers, other than transformers in bridge circuits, shall have primaries wound for voltage available and secondaries wound for correct control circuit voltage. Size transformers so that 80 percent of rated capacity equals connected load. Provide fuses in each ungrounded primary feeder. One secondary lead shall be fused; other shall be grounded.

2.19.4 Enclosures for Motor Controllers

NEMA ICS 6.

2.19.5 Pushbutton Stations

Provide with "start/stop" momentary contacts having one normally open and one normally closed set of contacts, and red lights to indicate when motor is running, green to indicate when motor is not running. Stations shall be heavy duty, oil-tight design.

2.19.6 Pilot and Indicating Lights

Provide LED lamps, each with multiple LEDs, with a minimum intensity of 200 mini-candelas, and a minimum life of 50,000 hours.

2.20 MANUAL MOTOR STARTERS (MOTOR RATED SWITCHES)

Single or double-pole, as indicated, designed for flush or surface mounting, as indicated, with overload protection and pilot lights. manual motor controlleers shall be quick make, quick break toggle switch type with overload elements and pilot light.

2.21 MOTOR CONTROL CENTERS

UL 845, NEMA ICS 2, NEMA ICS 3. Wiring shall be Class I, TypeB, in NEMA Type 1 enclosure. Provide control centers suitable for operation on 480-volt, 3-phase, 3-wire, 60 Hz system and shall have minimum short-circuit withstand and interrupting rating of 42,000 amperes rms symmetrical. Incoming power feeder shall be cable entering at the top or bottom of enclosure and terminating on terminal lugs or main protective

device. Main protective device shall be molded case circuit breaker rated at 42,000 amperes rms symmetrical interrupting capacity. Interconnecting wires shall be copper. Terminal blocks shall be plug-in-type so that controllers may be removed without disconnecting individual control wiring. Sections: The first and last vertical sections shall have a removable end plate for future extension of the motor control center and motor control center horizontal bus.

Compartments: Modular, with individual doors with concealed hinges and quick-captive screw fasteners. Provide interlocks for combination starter units so that the disconnect means must be in the off position before door can be opened, and so door cannot be closed with the disconnect means in the on position, except by consciously operating a permissive release device, which is arranged to be evident only to qualified persons.

Interchangeability: Construct compartments so it is possible to remove units without opening adjacent doors, disconnecting adjacent compartments, or disturbing the operation of other units in the control center. Units requiring the same size compartment shall be interchangeable, and compartments shall be constructed to permit ready rearrangement of units, such as replacing 3 single units with a unit requiring 3 spaces, without cutting or welding.

Wiring Spaces: Provide each vertical section of structure with horizontal and vertical wiring spaces for wiring to each unit compartment in each section. Provide supports to hold wiring rigidly in place.

2.21.1 Bus Systems

Provide the following bus systems. Power bus, both horzontal and vertical, shall be braced to withstand fault current of 42,000 amperes rms symmetrical. Wiring troughs shall be isolated from horizontal and vertical bus bars.

2.21.1.1 Horizontal and Main Buses

Horizontal bus shall have continuous current rating, as indicated. Main bus shall be copper, silver-plated enclosed in isolated compartment at top of each vertical section. Main bus shall be isolated from wire troughs, starters, and other areas.

2.21.1.2 Vertical Bus

Vertical bus shall have continuous current rating sufficient for a fully-loaded vertical section, but not less than 1/2 of the horizontal bus. Vertical bus shall be enclosed in flame-retardant, polyester glass "sandwich."

2.21.1.3 Ground Bus

Copper ground bus shall be provided full width of motor control center and shall be equipped with necessary lugs. The Ground bus shall be Non-insulated, horizontal copper bus 2-inches by 1/4-inch, or 12-1/2 percent of main phase bus rating, whichever is larger.

2.21.1.4 Neutral Bus

Insulated neutral bus,when provided on 4 Wire configurations, shall be provided continuous through the motor control center; neutral shall be full rated. Lugs of appropriate capacity shall be provided, as required.

2.20.1.4.1 Buss Extension

The first and last sections shall have a removable plate for future extension of the motor control center horizontal bus.

2.21.2 Motor Disconnecting Devices and Controllers

Shall comply with paragraph COMBINATION MOTOR CONTROLLERS.

2.21.3 Combination Motor Controllers

UL 508 and other requirements in paragraph, MOTOR CONTROLLERS. Controller shall employ molded case circuit breakers. Minimum short circuit withstand rating of combination motor controller shall be 65,000 rms symmetrical amperes.Circuit breakers for combination controllers shall be magnetic only.

2.22 LOCKOUT REQUIREMENTS

Provide disconnecting means capable of being locked out for machines and other equipment to prevent unexpected startup or release of stored energy in accordance with 29 CFR 1910.147. Mechanical isolation of machines and other equipment shall be in accordance with requirements of Division 15, "Mechanical."

2.23 TELECOMMUNICATIONS SYSTEM

Provide system of telecommunications wire-supporting structures (pathway), including: outlet boxes, conduits with pull wires wireways, cable trays, and other accessories for telecommunications outlets and pathway in accordance with EIA TIA/EIA-569-A and as specified herein. Additional telecommunications requirements are specified in Section 16710, BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

2.24 GROUNDING AND BONDING EQUIPMENT

2.24.1 Ground Rods

UL 467. Ground rods shall be sectional type, copper-clad steel, with minimum diameter of 3/4 inch and minimum length of 10 feet.

2.24.2 Ground Bus

A copper ground bus shall be provided in the electrical equipment rooms as indicated.

2.24.3 Telecommunications and CATV Grounding Busbar

Provide corrosion-resistant grounding busbar suitable for indoor installation in accordance with TIA J-STD-607-A. Busbars shall be electrotin-plated for reduced contact resistance. If not plated, the busbar shall be cleaned prior to fastening the conductors to the busbar, and an anti-oxidant shall be applied to the contact area to control corrosion and reduce contact resistance. Provide ground bars and systems as indicated in the drawings. Provide telecommunications grounding busbars with the following:

a. Predrilled copper busbar provided with holes for use with standard sized lugs,

b. Minimum dimensions, as indicated on the drawings;

c. Listed by a nationally recognized testing laboratory.

2.25 HAZARDOUS LOCATIONS

Electrical materials, equipment, and devices for installation in hazardous locations, as defined by NFPA 70, shall be specifically approved by Underwriters' Laboratories, Inc., or Factory Mutual for particular "Class," "Division," and "Group" of hazardous locations involved. Boundaries and classifications of hazardous locations shall be as indicated. Equipment in hazardous locations shall comply with UL 877 for circuit breakers, UL 886 for outlet boxes and fittings, UL 1010 for receptacles, UL 674 for motors, and UL 698 for industrial controls.

2.26 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.27 FIELD FABRICATED NAMEPLATES

ASTM D 709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 0.125 inch thick, white with black center core. Surface shall be matte finish.

Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be one by 2.5 inches. Lettering shall be a minimum of 0.25 inch high normal block style.

2.28 WARNING SIGNS

Provide warning signs for flash protection in accordance with NFPA 70E and NEMA Z535.4 for switchboards, panelboards, industrial control panels, and motor control centers that are in other than dwelling occupancies and are likely to require examination, adjustment, servicing, or maintenance while energized. Provide field installed signs to warn qualified persons of potential electric arc flash hazards when warning signs are not provided by the manufacturer. The marking shall be clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.

2.29 FIRESTOPPING MATERIALS

Provide firestopping around electrical penetrations in accordance with Section 07840 FIRESTOPPING .

2.30 WIREWAYS

UL 870. Material shall be steel epoxy painted 16 gauge for heights and depths up to 6 by 6 inches, and 14 gauge for heights and depths up to 12 by 12 inches. Provide in length required for the application with hingedcover NEMA 1 enclosure per NEMA ICS 6.

2.31 SURGE PROTECTIVE DEVICES

Provide parallel type surge protective devices which comply with UL 1449 Second Edition at the service entrance, unit substations, panelboards serving computer loads, and panelboard serving exterior loads. Provide surge protectors in a NEMA 1 enclosure per NEMA ICS 6. Provide the following modes of protection:

FOR SINGLE PHASE AND THREE PHASE WYE CONNECTED SYSTEMS
- Each phase to neutral (L-N)
- Neutral to ground (N-G)
- Phase to ground (L-G)

FOR DELTA CONNECTIONS
- Phase to phase (L-L)
- Phase to ground (L-G)

Surge protective devices at the service entrance shall have a minimum surge current rating of 80,000 amperes per mode minimum and downstream protectors shall be rated 40,000 amperes per mode minimum. The maximum line to neutral (L-N) Suppressed Voltage Rating (SVR) shall be:

500V for 120V, single phase system
500V for 120/240V, single phase system
500V for 208Y/120V, three phase system
900V for 480Y/277V, three phase system

The minimum MCOV (Maximum Continuous Operating Voltage) rating shall be:

150V for 120V, single phase system
300/150V for 120/240V, single phase system
300/150V for 208Y/120V, three phase system
600/320V for 480Y/277V, three phase system

EMI/RFI filtering shall be provided for each mode with the capability to attenuate high frequency noise. Minimum attenuation shall be 20db.

2.32 FACTORY APPLIED FINISH

Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test and the additional requirements as specified herein. Interior and exterior steel surfaces of equipment enclosures shall be thoroughly cleaned and then receive a rust-inhibitive phosphatizing or equivalent treatment prior to painting. Exterior surfaces shall be free from holes, seams, dents, weld marks, loose scale or other imperfections. Interior surfaces shall receive not less than one coat of corrosion-resisting paint in accordance with the manufacturer's standard practice. Exterior surfaces shall be primed, filled where necessary, and given not less than two coats baked enamel with semigloss finish. Equipment located indoors shall be ANSI Light Gray, and equipment located outdoors shall be ANSI Dark Gray. Provide manufacturer's coatings for touch-up work and as specified in paragraph FIELD APPLIED PAINTING.

2.33 SOURCE QUALITY CONTROL

2.33.1 Transformer Factory Tests

Submittal shall include routine NEMA ST 20 transformer test results on each transformer and also contain the results of NEMA "design" and "prototype" tests that were made on transformers electrically and mechanically equal to those specified.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations, including weatherproof and hazardous locations and ducts, plenums and other air-handling spaces, shall conform to requirements of NFPA 70 and IEEE C2 and to requirements specified herein. The use of dry type transformers shall be restricted to indoors areas not subject to weather; Liquid filled transformers shall be used outdoors and rated as such.

3.1.1 Hazardous Locations

Work in hazardous locations, as defined by NFPA 70, shall be performed in strict accordance with NFPA 70 for particular "Class," "Division," and "Group" of hazardous locations involved. Provide conduit and cable seals where required by NFPA 70. Conduit shall have tapered threads.

3.1.2 Service Entrance Identification

Service entrance disconnect devices, switches, and enclosures shall be labeled and identified as such.

3.1.2.1 Labels

Wherever work results in service entrance disconnect devices in more than one enclosure, as permitted by NFPA 70, each enclosure, new and existing, shall be labeled as one of several enclosures containing service entrance disconnect devices. Label, at minimum, shall indicate number of service disconnect devices housed by enclosure and shall indicate total number of enclosures that contain service disconnect devices. Provide laminated plastic labels conforming to paragraph FIELD FABRICATED NAMEPLATES. Use lettering of at least 0.25 inch in height, and engrave on black-on-white matte finish. Service entrance disconnect devices in more than one enclosure, shall be provided only as permitted by NFPA 70.

3.1.2.2 Clearances

NEC working clearances shall be adequately marked in all electrical equipment room with a 1" wide painted line. The Words" Minimum Working Clearances" in 1 1/2" letters shall be painted using the same yellow color within the clear area.

3.1.2.3 Feeder Cable/Conduit Labeling

1. The feeder conductors shall be labelled using in the format below.
Example: 3-2C350-1C350-1C1/0-THHN-100-CN

2. Each section of text separated by dashes is a group. Each group has a dedicated meaning as shown in the table below.

3. Each group is subdivided into identifiers. Each identifier must follow the coding convention presented below.

a. Phase Information:
   i. Number of Phases

b. Phase Conductor Information:
   i. Number of Phase Conductors
   ii. Conductor Material (shall follow the codes given below)
   iii. Phase Conductor Size (shall follow the codes given below)

c. Neutral Conductor Information:
   i. Number of Neutral Conductors
   ii. Conductor Material (shall follow the codes given below)
   iii. Neutral Conductor Size (shall follow the codes given below)

d. Ground Conductor Information:
   i. Number of Ground Conductors
   ii. Conductor Material (shall follow the codes given below)
   iii. Ground Conductor Size (shall follow the codes given below)

e. Insulation Type (shall follow the codes given below)

f. % Insulation (shall follow the codes given below) (Only required for MV Cable)

g. Shielding Type (shall follow the codes given below) (Only required for MV Cable)

4. Codes for “Conductor Size”

a. 12 - #12 AWG
b. 10 - #10 AWG
c. 8 - #8 AWG
d. 6 - #6 AWG

e. 4 - #4 AWG
f. 2 - #2 AWG
g. 1 - #1 AWG
h. 1/0 - 0 AWG
i. 2/0 - 00 AWG
j. 3/0 - 000 AWG
k. 4/0 - 0000 AWG
l. 250 - 250 kcmil
m. 300 - 300 kcmil
n. 350 - 350 kcmil
o. 400 - 400 kcmil
p. 500 - 500 kcmil
q. 600 - 600 kcmil
r. 700 - 700 kcmil
s. 750 - 750 kcmil
t. 800 - 800 kcmil
u. 900 - 900 kcmil
v. 1000 - 1000 kcmil
w. 1250 - 1250 kcmil
x. 1500 - 1500 kcmil
y. 1750 - 1750 kcmil
z. 2000 - 2000 kcmil

5. Codes for “Conductor Material”
    a. A – Aluminum
    b. C – Copper
6. Codes for “Insulation Type”
    a. FEP – Fluorinated Ethylene Propylene
    b. FEPB – Fluorinated Ethylene Propylene
    c. MI – Mineral Insulation
    d. MTW – Moisture-, Heat-, and Oil-Resistant Thermoplastic
    e. P – Paper
    f. PFA – Perfluoro-alkoxy
    g. PFAH – Perfluoro-alkoxy
    h. RHH – Thermoset
    i. RHW – Moisture-Resistant Thermoset
    j. RHW2 – Moisture-Resistant Thermoset
    k. SA – Silicone
    l. SIS – Thermoset
    m. TBS – Thermoplastic and Fibrous Outer Braid
    n. TFE – Extended Polytetra-Fluoro-Ethylene
    o. THHN – Heat-Resistant Thermoplastic
    p. THHW – Moisture- and Heat-Resistant Thermoplastic
    q. THW – Moisture- and Heat-Resistant Thermoplastic
    r. THWN – Moisture- and Heat-Resistant Thermoplastic
    s. TW – Moisture-Resistant Thermoplastic
    t. UF – Underground Feeder and Branch-Circuit Cable (Single Conductor
    u. USE – Underground Service Entrance Cable (Single Conductor)
    v. XHH – Thermoset
    w. XHHW – Moisture-Resistant Thermoset
    x. XHHW2 – Moisture-Resistant Thermoset
    y. Z – Modified Ethylene Tetrafluoro-Ethylene
    z. ZW – Modified Ethylene Tetrafluoro-Ethylene
    7. Codes for “% Insulation”
    a. 100 – 100%
    b. 133 – 133%
    8. Codes for “Shielding Type”
    a. CN – Concentric Neutral
    b. SW – Spiral Wound
    c. T – Tape

3.1.3 Wiring Methods

Provide insulated conductors installed in rigid steel conduit, IMC, rigid nonmetallic conduit, or EMT, except where specifically indicated or specified otherwise or required by NFPA 70 to be installed otherwise. Grounding conductor shall be separate from electrical system neutral conductor. Type MC (metal Clad cable) is acceptable in concealed locations when installed in accordance with NFPA 70. Provide fire rated type MC cable for all life safety circuits.

Provide insulated green equipment grounding conductor for circuit(s) installed in conduit and raceways. Minimum conduit size shall be 3/4 inch in diameter for low voltage lighting and power circuits. Vertical distribution in multiple story buildings shall be made with metal conduit in fire-rated shafts. Metal conduit shall extend through shafts for minimum distance of 6 inches. Provide a separate neutral conductor for each 120 branch circuit with the exception of lighting and convenience receptacles. Conduit which penetrates fire-rated walls, fire-rated partitions, or fire-rated floors shall be firestopped in accordance with Section 07840 FIRESTOPPING.

3.1.3.1 Pull Wire

Install pull wires in empty conduits. Pull wire shall be plastic having minimum 200-pound force tensile strength. Leave minimum 36 inches of slack at each end of pull wire.

3.1.3.2 Metal Clad Cable

Install in accordance with NFPA 70, Type MC cable.

3.1.3.3 Fire rated MC cable

Install in accordance with NFPA 70, Type MC cable.

3.1.3.3.1 Lugs

All lugs shall be compression type

3.1.4 Conduit Installation

Unless indicated otherwise, conceal conduit under floor slabs and within finished walls, ceilings, and floors. Keep conduit minimum 6 inches away from parallel runs of flues and steam or hot water pipes. Install conduit parallel with or at right angles to ceilings, walls, and structural members where located above accessible ceilings and where conduit will be visible after completion of project.

3.1.4.1 Raceway Types

1. Acceptable raceway types shall be the following:
2. IMC – Intermediate Metal Conduit
3. EMT – Electrical Metallic Tubing
4. MC – Metal Clad
5. FMC – Flexible Metal Conduit
6. LFMC – Liquidtight Flexible Metal Conduit
7. RMC – Rigid Metal Conduit
8. IMC shall be used for fire alarm and security system wiring,and EMT may be embedded in cementitious material where noted or show in drawing details.
9. EMT shall be used for all main feeders concealed above ceilings and in walls and for telephone/data wiring.
10. EMT shall be used for feeders from the distribution panel to a PDU.
11. Nonmetallic conduit (schedule 40) where specifically indicated on the drawings.
12 MC cable shall be used for all branch circuits feeding

lighting fixtures from junction boxes to each fixture and for wiring from
under floor boxes to receptacles mounted in Liskey boxes.
13 FMC or LFMC shall be used for connections to motors, transformers, machinery, lighting and other equipment subject to vibration. Length shall
not exceed 3 feet.

3.1.4.2 Restrictions Applicable to Aluminum Conduit

a. Do not install underground or encase in concrete or masonry.
b. Do not use brass or bronze fittings.
c. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.4.3 Restrictions Applicable to EMT

a. Do not install underground.

b. Do not encase in concrete, mortar, grout, or other cementitious materials.

c. Do not use in areas subject to severe physical damage including but not limited to equipment rooms where moving or replacing equipment could physically damage the EMT.

d. Do not use in hazardous areas.

e. Do not use outdoors.

f. Do not use in fire pump rooms.

g. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.4.4 Restrictions Applicable to Nonmetallic Conduit

a. PVC Schedule 40 and PVC Schedule 80

(1) Do not use in areas where subject to severe physical damage, including but not limited to, mechanical equipment rooms, electrical equipment rooms, power plants, and other such areas.
(2) Do not use in hazardous (classified) areas.
(3) Do not use in fire pump rooms.
(4) Do not use in penetrating fire-rated walls or partitions, or fire-rated floors.
(5) Do not use above grade, except where allowed in this section for rising through floor slab or indicated otherwise.
(6) Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).
(7) Do not use within plenums or other areas restricted per NEC

3.1.4.5 Restrictions Applicable to Flexible Conduit

Use only as specified in paragraph FLEXIBLE CONNECTIONS. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.4.6 Service Entrance Conduit, Underground

PVC, Type-EPC 40, galvanized rigid steel or steel IMC. Underground portion shall be encased in minimum of 3 inches of concrete and shall be installed minimum 18 inches below slab or grade.

3.1.4.7 Underground Conduit Other Than Service Entrance

PVC, Type EPC-40. Convert nonmetallic conduit, other than PVC Schedule 40 or 80, to plastic-coated rigid, or IMC, steel conduit before rising through floor slab. Plastic coating shall extend minimum 6 inches above floor.

3.1.4.8 Conduit for Circuits Rated Greater Than 600 Volts

PVC Schedule 40 or 80 in concrete where below grade or slab. Rigid metal conduit or IMC only. Where exposed, painted orange.

3.1.4.9 Conduit Installed Under Floor Slabs

Conduit run under floor slab shall be located below the vapor barrier. Seal around conduits at penetrations thru vapor barrier.

3.1.4.10 Conduit Through Floor Slabs

Where conduits rise through floor slabs, curved portion of bends shall not be visible above finished slab.

3.1.4.11 Stub-Ups

Provide conduits stubbed up through concrete floor for connection to free-standing equipment with adjustable top or coupling threaded inside for plugs, set flush with finished floor. Extend conductors to equipment in rigid steel conduit, except that flexible metal conduit may be used 6 inches above floor. Where no equipment connections are made, install screwdriver-operated threaded flush plugs in conduit end.

3.1.4.12 Conduit Support

Support conduit by pipe straps, wall brackets, hangers, or ceiling trapeze. Fasten by wood screws to wood; by toggle bolts on hollow masonry units; by concrete inserts or expansion bolts on concrete or brick; and by machine screws, welded threaded studs, or spring-tension clamps on steel work. Threaded C-clamps may be used on rigid steel conduit only. Do not weld conduits or pipe straps to steel structures. Load applied to fasteners shall not exceed one-fourth proof test load. Fasteners attached to concrete ceiling shall be vibration resistant and shock-resistant. Holes cut to depth of more than 1 1/2 inches in reinforced concrete beams or to depth of more than 3/4 inch in concrete joints shall not cut main reinforcing bars. Fill unused holes. In partitions of light steel construction, use sheet metal screws. In suspended-ceiling construction, run conduit above ceiling. Do not support conduit by ceiling support system. Conduit and box systems shall be supported independently of both (a) tie wires supporting ceiling grid system, and (b) ceiling grid system into which ceiling panels are placed. Supporting means shall not be shared between electrical raceways and mechanical piping or ducts. Installation shall be coordinated with above-ceiling mechanical systems to assure maximum accessibility to all systems. Spring-steel fasteners may be used for lighting branch circuit conduit supports in suspended ceilings in dry locations. Support exposed risers in wire shafts of multistory buildings by U-clamp hangers at each floor level and at 10 foot maximum intervals. Where conduit crosses building expansion joints, provide suitable expansion fitting that maintains conduit electrical continuity by bonding jumpers or other means. For conduits greater than 2 1/2 inches inside diameter, provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

3.1.4.13 Directional Changes in Conduit Runs

Make changes in direction of runs with symmetrical bends or cast-metal fittings. Make field-made bends and offsets with hickey or conduit-bending machine. Do not install crushed or deformed conduits. Avoid trapped conduits. Prevent plaster, dirt, or trash from lodging in conduits, boxes, fittings, and equipment during construction. Free clogged conduits of obstructions.

3.1.4.14 Locknuts and Bushings

Fasten conduits to sheet metal boxes and cabinets with two locknuts where required by NFPA 70, where insulated bushings are used, and where bushings cannot be brought into firm contact with the box; otherwise, use at least minimum single locknut and bushing. Locknuts shall have sharp edges for digging into wall of metal enclosures. Install bushings on ends of conduits, and provide insulating type where required by NFPA 70.

3.1.4.15 Flexible Connections

Provide flexible steel conduit or Type MC cable between 3 and 6 feet in length for recessed and semirecessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for motors. Install flexible conduit to allow 20 percent slack. Minimum flexible steel conduit size shall be 1/2 inch diameter; maximum length, with the exception of security doors, shall be 3 feet without engineering approval.. Provide liquidtight flexible conduit in wet and damp locations for equipment subject to vibration, noise transmission, movement or motors. Provide separate ground conductor across flexible connections.

3.1.4.16 Telecommunications and Signal System Pathway

Install telecommunications pathway in accordance with EIA TIA/EIA-569-A.

a. Horizontal Pathway: Telecommunications pathways from the work area to the telecommunications room shall be installed and cabling length requirements in accordance with EIA TIA/EIA-568-B.1. Size conduits, wireways, and cable trays in accordance with EIA TIA/EIA-569-A or as indicated.

b. Backbone Pathway: Telecommunication pathways from the telecommunications entrance facility to telecommunications rooms, and, telecommunications equipment rooms (backbone cabling) shall be installed in accordance with EIA TIA/EIA-569-A. Size conduits, wireways, and cable trays for telecommunications risers in accordance with EIA TIA/EIA-569-A or as indicated.

3.1.5 Cable Tray Installation

Install and ground in accordance with NFPA 70. In addition, install and ground telecommunications cable tray in accordance with EIA TIA/EIA-569-A, and TIA J-STD-607-A. Install cable trays parallel with or at right angles to ceilings, walls, and structural members. Support in accordance with manufacturer recommendations but at not more than 6 foot intervals. Contact surfaces of aluminum connections shall be coated with an antioxidant compound prior to assembly. Adjacent cable tray sections shall be bonded together by connector plates of an identical type as the cable tray sections. For grounding of cable tray system provide copper wire throughout cable tray system, and bond to each section. The tray grounding

conductor shall be sized in accordance with the recomendations of TIA/EIA standards. Use aluminum wire if cable tray is aluminum. Terminate cable trays 10 inches from both sides of smoke and fire partitions. Conductors run through smoke and fire partitions shall be installed in 4 inch rigid steel conduits with grounding bushings, extending 12 inches beyond each side of partitions. Seal conduit on both ends to maintain smoke and fire ratings of partitions. Penetrations shall be firestopped in accordance with Section 07840 FIRESTOPPING. Provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

3.1.6 Telecommunications Cable Support Installation

Install open top and closed ring cable supports on 4 ft to 5 ft centers to adequately support and distribute the cable’s weight. These types of supports shall be used to support a maximum of 50 0.25 in diameter cables. Install suspended cables with at least 3 in of clear vertical space above the ceiling tiles and support channels (T-bars). Open top and closed ring cable supports shall be suspended from or attached to the structural ceiling or walls with hardware or other installation aids specifically designed to support their weight.

3.1.7 Boxes, Outlets, and Supports

Provide boxes in wiring and raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures. Boxes for metallic raceways shall be cast-metal, hub-type when located in wet locations, when surface mounted on outside of exterior surfaces, when surface mounted on interior walls exposed up to 7 feet above floors and walkways, or when installed in hazardous areas and when specifically indicated. Boxes in other locations shall be sheet steel, except that aluminum boxes may be used with aluminum conduit, and nonmetallic boxes may be used with nonmetallic conduit system. Each box shall have volume required by NFPA 70 for number of conductors enclosed in box. Boxes for mounting lighting fixtures shall be minimum 4 inches square, or octagonal, except that smaller boxes may be installed as required by fixture configurations, as approved. Boxes for use in masonry-block or tile walls shall be square-cornered, tile-type, or standard boxes having square-cornered, tile-type covers. Provide gaskets for cast-metal boxes installed in wet locations and boxes installed flush with outside of exterior surfaces. Provide separate boxes for flush or recessed fixtures when required by fixture terminal operating temperature; fixtures shall be readily removable for access to boxes unless ceiling access panels are provided. Support boxes and pendants for surface-mounted fixtures on suspended ceilings independently of ceiling supports. Fasten boxes and supports with wood screws on wood, with bolts and expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screws or welded studs on steel. In open overhead spaces, cast boxes threaded to raceways need not be separately supported except where used for fixture support; support sheet metal boxes directly from building structure or by bar hangers. Where bar hangers are used, attach bar to raceways on opposite sides of box, and support raceway with approved-type fastener maximum 24 inches from box. When penetrating reinforced concrete members, avoid cutting reinforcing steel.

3.1.7.1 Boxes

Boxes for use with raceway systems shall be minimum 1 1/2 inches deep, except where shallower boxes required by structural conditions are approved. Boxes for other than lighting fixture outlets shall be minimum 4 inches square, except that 4 by 2 inch boxes may be used where only one raceway enters outlet. Telecommunications outlets shall be a minimum of 4 inches square by 2 1/8 inches deep, except for wall mounted telephones and outlet boxes for handicap telephone stations. Mount outlet boxes flush in finished walls.

3.1.7.2 Pull Boxes

Construct of at least minimum size required by NFPA 70 of code-gauge aluminum or galvanized sheet steel, except where cast-metal boxes are required in locations specified herein. Provide boxes with screw-fastened covers. Where several feeders pass through common pull box, tag feeders to indicate clearly electrical characteristics, circuit number, and panel designation.

3.1.7.3 Extension Rings

Extension rings are not permitted for new construction with the allowable exception of Fire Alarm devices to obtain necessary depth of box. Use only on existing boxes in concealed conduit systems where wall is furred out for new finish.

3.1.8 Mounting Heights

Mount panelboards, enclosed circuit breakers, motor controller and disconnecting switches so height of operating handle at its highest position is maximum 78 inches above floor. Mount lighting switches and handicapped telecommunications stations 48 inches above finished floor. Mount receptacles and telecommunications outlets 18 inches above finished floor, unless otherwise indicated. Wall-mounted telecommunications outlets shall be mounted at the height indicated 60 inches above finished floor. Measure mounting heights of wiring devices and outlets in non-hazardous areas to center of device or outlet. Measure mounting heights of receptacle outlet boxes in the hazardous area to the bottom of the outlet box.

3.1.9 Fire rated MC Cable Installation

The wiring cable shall be installed according to the manufacturer’s recommendations,the instructions in the Manual and the requirements of the UL “Electrical Circuit Protection System” listing.

3.1.10 Conductor Identification

Provide conductor identification within each enclosure where tap, splice, or termination is made. For conductors No. 6 AWG and smaller diameter, color coding shall be by factory-applied, color-impregnated insulation. For conductors No. 4 AWG and larger diameter, color coding shall be by plastic-coated, self-sticking markers; colored nylon cable ties and plates; or heat shrink-type sleeves. Provide telecommunications system conductor identification as specified in Section 16710 BUILDING TELECOMMUNICATIONS CABLING SYSTEMS.

3.1.10.1 Marking Strips

White or other light-colored plastic marking strips, fastened by screws to each terminal block, shall be provided for wire designations. The wire numbers shall be made with permanent ink. The marking strips shall be

reversible to permit marking both sides, or two marking strips shall be furnished with each block. Marking strips shall accommodate the two sets of wire numbers. Each device to which a connection is made shall be assigned a device designation in accordance with NEMA ICS 1 and each device terminal to which a connection is made shall be marked with a distinct terminal marking corresponding to the wire designation used on the Contractor's schematic and connection diagrams. The wire (terminal point) designations used on the Contractor's wiring diagrams and printed on terminal block marking strips may be according to the Contractor's standard practice; however, additional wire and cable designations for identification of remote (external) circuits shall be provided for the Government's wire designations. Prints of the marking strips drawings submitted for approval will be so marked and returned to the Contractor for addition of the designations to the terminal strips and tracings, along with any rearrangement of points required.

3.1.11 Splices

Make splices in accessible locations. Make splices in conductors No. 10 AWG and smaller diameter with insulated, pressure-type connector. Make splices in conductors No. 8 AWG and larger diameter with solderless connector, and cover with insulation material equivalent to conductor insulation.

3.1.12 Covers and Device Plates

Install with edges in continuous contact with finished wall surfaces without use of mats or similar devices. Plaster fillings are not permitted. Install plates with alignment tolerance of 1/16 inch. Use of sectional-type device plates are not permitted. Provide gasket for plates installed in wet locations.

3.1.13 Electrical Penetrations

Seal openings around electrical penetrations through fire resistance-rated walls, partitions, floors, or ceilings in accordance with Section 07840 FIRESTOPPING.

3.1.14 Grounding and Bonding

Provide In accordance with NFPA 70 and NFPA 780. Ground exposed, non-current-carrying metallic parts of electrical equipment, access flooring support system, metallic raceway systems, grounding conductor in metallic and nonmetallic raceways, telecommunications system grounds, and neutral conductor of wiring systems. Make ground connection at main service equipment, and extend grounding conductor to point of entrance of metallic water service. Make connection to water pipe by suitable ground clamp or lug connection to plugged tee. If flanged pipes are encountered, make connection with lug bolted to street side of flanged connection. Supplement metallic water service grounding system with additional made electrode in compliance with NFPA 70. Make ground connection to driven ground rods on exterior of building. Interconnect all grounding media in or on the structure to provide a common ground potential. This shall include lightning protection, electrical service, telecommunications system grounds, as well as underground metallic piping systems. Interconnection to the gas line shall be made on the customer's side of the meter. Use main size lightning conductors for interconnecting these grounding systems to the lightning protection system. Where ground fault protection is employed, ensure that connection of ground and neutral does not interfere with correct operation of fault protection.

3.1.14.1 Ground Rods

Provide cone pointed ground rods. The resistance to ground shall be measured using the fall-of-potential method described in IEEE Std 81.

3.1.14.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible, excepting specifically those connections for which access for periodic testing is required, by exothermic weld or compression connector.

a. Make exothermic welds strictly in accordance with the weld manufacturer's written recommendations. Welds which are "puffed up" or which show convex surfaces indicating improper cleaning are not acceptable. Mechanical connectors are not required at exothermic welds.

b. Make compression connections using a hydraulic compression tool to provide the correct circumferential pressure. Tools and dies shall be as recommended by the manufacturer. An embossing die code or other standard method shall provide visible indication that a connector has been adequately compressed on the ground wire.

3.1.14.3 Ground Bus

A copper ground bus shall be provided in the electrical equipment rooms as indicated. Noncurrent-carrying metal parts of transformer neutrals and other electrical equipment shall be effectively grounded by bonding to the ground bus. The ground bus shall be bonded to both the entrance ground, and to a ground rod or rods as specified above having the upper ends terminating approximately 4 inches above the floor. Connections and splices shall be of the brazed, welded, bolted, or pressure-connector type, except that pressure connectors or bolted connections shall be used for connections to removable equipment. For raised floor equipment rooms in computer and data processing centers, a minimum of 4, one at each corner, ground buses shall be provided and connected to the building grounding system. Connections shall be bolted type in lieu of thermoweld, so they can be changed as required by additions and/or alterations.

3.1.15 Equipment Connections

Provide power wiring for the connection of motors and control equipment under this section of the specification. Except as otherwise specifically noted or specified, automatic control wiring, control devices, and protective devices within the control circuitry are not included in this section of the specifications but shall be provided under the section specifying the associated equipment.

3.1.16 Elevator

Provide circuit to line terminals of elevator controller, and disconnect switch on line side of controller, outlet for control power, outlet receptacle and work light and outlet receptacle in elevator pit.

3.1.17 Government-Furnished Equipment

Contractor shall rough-in for Government-furnished equipment and shall make

connections to Government-furnished equipment] to make equipment operate as intended, including providing miscellaneous items such as plugs, receptacles, wire, cable, conduit, flexible conduit, and outlet boxes or fittings.

3.1.18 Repair of Existing Work

3.1.18.1 Workmanship

Lay out work in advance. Exercise care where cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, or other surfaces is necessary for proper installation, support, or anchorage of conduit, raceways, or other electrical work. Repair damage to buildings, piping, and equipment using skilled craftsmen of trades involved.

3.1.19 Surge Protective Devices

Connect the surge protective devices in parallel to the power source, keeping the conductors as short and straight as practically possible.

3.2 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.3 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side. Space the signs in accordance with NFPA 70E.

3.4 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting shall be as specified in Section 09900 PAINTS AND COATINGS.

3.5 COLOR SCHEMES

The following color schemes have been coordinated with the other disciplines and shall be used for marking and labeling purposes.

3.5.1 Conduits

Conduits for the following color schemes shall be marked with the appropriate color at each end of the run and every 10 feet thereafter for the full length of the conduit. These markings shall be a minimum of 8 inches long and encircle the conduit. High Voltage conduits within buildings shall be painted in their entirety. Each piece of equipment shall be marked with a 3 inch stripe of the color indicated below at the top and bottom.

3.5.2 Junction Boxes

Junction Boxes shall be painted in their entirety.

3.5.3 Colors

a. Data Center power shall be color coded in accordance with 16265 3.2.1.1

b. Red - Fire Alarm
c. Orange - High Voltage (medium voltage)
d. Blue - primary Chilled Water
e. Light Blue Secondary Chilled Water
f. Grey - Stream
g. White - Domestic Water
h. Green - Condenser Water

3.6 FIELD QUALITY CONTROL

Furnish test equipment and personnel and submit written copies of test results. Give Contracting Officer 5 working days notice prior to each test.

3.6.1 Devices Subject to Manual Operation

Each device subject to manual operation shall be operated at least five times, demonstrating satisfactory operation each time.

3.6.2 600-Volt Wiring Test

Test wiring rated 600 volt and less to verify that no short circuits or accidental grounds exist. Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of approximately 500 volts to provide direct reading of resistance. Minimum resistance shall be 250,000 ohms.

3.6.3 Transformer Tests

Perform the standard, not optional, tests in accordance with the Inspection and Test Procedures for transformers, dry type, air-cooled, 600 volt and below; as specified in NETA ATS. Measure primary and secondary voltages for proper tap settings. Tests need not be performed by a recognized independent testing firm or independent electrical consulting firm.

3.6.4 Ground-Fault Receptacle Test

Test ground-fault receptacles with a "load" (such as a plug in light) to verify that the "line" and "load" leads are not reversed.

3.6.5 Grounding System Test

Test grounding system to ensure continuity, and that resistance to ground is not excessive. Test each ground rod for resistance to ground before making connections to rod; tie grounding system together and test for resistance to ground. Make resistance measurements in dry weather, not earlier than 48 hours after rainfall. Submit written results of each test to Contracting Officer, and indicate location of rods as well as resistance and soil conditions at time measurements were made.

-- End of Section --

SECTION 16410
AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH
04/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM B 117	(2002) Operating Salt Spray (Fog) Apparatus

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C37.13	(1990; R 1995) Low-Voltage AC Power Circuit Breakers Used in Enclosures
IEEE C37.90.1	(2002) Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
IEEE C62.41	(1991; R 1995) Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits
IEEE Std 602	(1996) Recommended Practice for Electric Systems in Health Care Facilities - White Book

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 1	(2000; R 2005) Industrial Control and Systems: General Requirements
NEMA ICS 10	(1999; R 2000) Industrial Control and Systems: AC Transfer Switch Equipment
NEMA ICS 2	(1996; R 2004) Standard for Industrial Control and Systems: Controllers, Contractors, and Overload Relays Rated Not More than 2000 Volts AC or 750 Volts DC: Part 8 - Disconnect Devices for Use in Industrial Control Equipment
NEMA ICS 4	(2000) Industrial Control and Systems: Terminal Blocks
NEMA ICS 6	(1993; R 2001) Industrial Control and Systems: Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 110	(2005) Emergency and Standby Power Systems
NFPA 70	(2005) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 1008	(1996; Rev thru Aug 2003) Transfer Switch Equipment
UL 1066	(1997) Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. he following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings

Schematic, external connection, one-line schematic and wiring diagram of each ATS assembly.

Equipment

Installation

Dimensioned plans, sections and elevations showing minimum clearances, weights, and conduit entry provisions for each ATS.

SD-03 Product Data

Material

Equipment

List of proposed equipment and material, containing a description of each separate item.

SD-06 Test Reports

Testing; G

A description of proposed field test procedures, including proposed date and steps describing each test, its duration and expected results, not less than two weeks prior to test date. Certified factory and field test reports, within 14 days following completion of tests. Reports shall be certified and dated and shall demonstrate that tests were successfully completed prior to shipment of equipment.

SD-07 Certificates

Equipment

Material

Certificates of compliance showing evidence of UL listing and conformance with applicable NEMA standards. Such certificates are not required if manufacturer's published data, submitted and approved, reflect UL listing or conformance with applicable NEMA standards.

Switching Equipment

Evidence that ATS withstand current rating (WCR) has been coordinated with upstream protective devices as required by UL 1008.

SD-10 Operation and Maintenance Data

Switching Equipment

Instructions

Six copies of operating and Six copies of maintenance manuals listing routine maintenance, possible breakdowns, repairs, and troubleshooting guide.

1.3 GENERAL REQUIREMENTS

1.3.1 Standard Product

Material and equipment shall be standard products of a manufacturer regularly engaged in manufacturing the products and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. The experience use shall include applications in similar circumstances and of same design and rating as specified ATS. Equipment shall be capable of being serviced by a manufacturer-authorized and trained organization that is, in the Contracting Officer's opinion, reasonably convenient to the site.

1.3.2 Nameplate

Nameplate showing manufacturer's name and equipment ratings shall be made of corrosion-resistant material with not less than 1/8 inch tall characters. Nameplate shall be mounted to front of enclosure and shall comply with nameplate requirements of NEMA ICS 2.

1.3.3 Detail Drawings

The Contractor shall submit interface equipment connection diagram showing conduit and wiring between ATS and related equipment. Device, nameplate, and item numbers shown in list of equipment and material shall appear on drawings wherever that item appears. Diagrams shall show interlocking provisions and cautionary notes, if any. Operating instructions shall be shown either on one-line diagram or separately. Unless otherwise approved, one-line and elementary or schematic diagrams shall appear on same drawing.

1.3.4 Switching Equipment

Upon request, manufacturer shall provide notarized letter certifying compliance with requirements of this specification, including withstand current rating (WCR). The Contractor shall submit an operating manual outlining step-by-step procedures for system startup, operation, and shutdown. Manual shall include manufacturer's name, model number, service manual, parts list, and brief description of equipment and basic operating features. Manufacturer's spare parts data shall be included with supply

source and current cost of recommended spare parts. Manual shall include simplified wiring and control diagrams for system as installed.

1.4 SERVICE CONDITIONS

Seismic requirements shall be as specified in Sections 13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT, 15070 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT and 16070 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT as indicated. ATS shall be suitable for prolonged performance under following service conditions:

a. Altitude: Less than 1000 feet above mean sea level.
b. Relative Humidity: 95 percent maximum, continuous.
c. Temperature: Minus 20 to 104 degrees F.
d. Seismic Parameters: Seismic Use Group IIIC.

PART 2 PRODUCTS

2.1 AUTOMATIC TRANSFER SWITCH (ATS)

ATS shall be electrically operated and mechanically held in both operating positions. ATS shall be suitable for use in emergency systems described in NFPA 70. ATS shall be UL listed. ATS shall be manufactured and tested in accordance with applicable requirements of IEEE C37.90.1, IEEE C37.13, IEEE C62.41, IEEE Std 602, NEMA ICS 1, NEMA ICS 2, NEMA ICS 10, Part 2, UL 1008 and UL 1066. ATS shall conform to NFPA 110. To facilitate maintenance, manufacturer's instruction manual shall provide typical maximum contact voltage drop readings under specified conditions for use during periodic maintenance. Manufacturer shall provide instructions for determination of contact integrity. ATS shall be rated for continuous duty at specified continuous current rating. ATS shall be fully compatible and approved for use with BP/IS specified. BP/IS shall be considered part of ATS system. ATS shall have following characteristics:

a. Voltage: 480/277 volts ac.

b. Number of Phases: Three.

c. Number of Wires: Three and Four.

d. Frequency: 60 Hz.

e. Poles: Three switched and solid neutral.

f. ATS WCR: Rated to withstand short-circuit current of 65,000 amperes, RMS symmetrical.

g. Nonwelding Contacts: Rated for nonwelding of contacts when used with upstream feeder overcurrent devices shown and with available fault current specified.

h. Main and Neutral Contacts: Contacts shall have silver alloy composition. Neutral contacts shall have same continuous current rating as main or phase contacts.

2.1.1 Override Time Delay

Time delay to override monitored source deviation shall be adjustable from 0.5 to 6 seconds and factory set at 1 second. ATS shall monitor phase conductors to detect and respond to sustained voltage drop of 15 percent of nominal between any two normal source conductors and initiate transfer action to emergency source and start engine driven generator after set time period. Pickup voltage shall be adjustable from 85 to 100 percent of nominal and factory set at 90 percent. Dropout voltage shall be adjustable from 75 to 98 percent of pickup value and factory set at 85 percent of nominal.

2.1.2 Transfer Time Delay

Time delay before transfer to emergency power source shall be adjustable from 0 to 5 minutes and factory set at minutes. ATS shall monitor frequency and voltage of emergency power source and transfer when frequency and voltage are stabilized. Pickup voltage shall be adjustable from 85 to 100 percent of nominal and factory set at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal and factory set at 90 percent.

2.1.3 Return Time Delay

Time delay before return transfer to normal power source shall be adjustable from 0 to 30 minutes and factory set at 15 minutes. Time delay shall be automatically defeated upon loss or sustained undervoltage of emergency power source, provided that normal supply has been restored.

2.1.4 Engine Shutdown Time Delay

Time delay shall be adjustable from 0 to 30 minutes and shall be factory set at 10 minutes.

2.1.5 Auxiliary Contacts

Two normally open and two normally closed auxiliary contacts rated at 20 amperes at 120 volts shall operate when ATS is connected to normal power source, and two normally open and two normally closed contacts shall operate when ATS is connected to emergency source.

2.1.6 Supplemental Features

ATS shall be furnished with the following:

a. Emergency source monitor.

b. Test switch to simulate normal power outage.

c. Voltage sensing. Pickup voltage adjustable from 85 to 100 percent of nominal; dropout adjustable from 75 to 98 percent of pickup.

d. Time delay bypass switch to override return time delay to normal.

e. Manual return-to-normal switch.

f. Means shall be provided in the ATS to insure that motor/transformer load inrush currents do not exceed normal starting currents. This shall be accomplished with either in-phase monitoring, time-delay transition, or load voltage decay sensing methods. If manufacturer supplies an in-phase monitoring system, the manufacturer shall indicate under what conditions a transfer cannot be accomplished. If the manufacturer supplies a time-delay transition system, the manufacturer shall supply recommendations for establishing time delay. If load voltage decay sensing is supplied, the load voltage setting shall be user programmable.

2.1.7 Operator

Manual operator conforming to UL 1008 shall be provided, and shall incorporate features to prevent operation by unauthorized personnel. ATS shall be designed for safe manual operation under full load conditions. If manual operation is accomplished by opening the door, then a dead-front shall be supplied for operator safety.

2.1.8 Override Switch

Override switch shall bypass automatic transfer controls so ATS will transfer and remain connected to emergency power source, regardless of condition of normal source. If emergency source fails and normal source is available, ATS shall automatically retransfer to normal source.

2.1.9 Green Indicating Light

A green indicating light shall supervise/provide normal power source switch position indication and shall have a nameplate engraved NORMAL.

2.1.10 Red Indicating Light

A red indicating light shall supervise/provide emergency power source switch position indication and shall have a nameplate engraved EMERGENCY.

2.2 BY-PASS/ISOLATION SWITCH (BP/IS)

2.2.1 Design

Bypass/isolation switch (BP/IS) shall permit load by-pass to either normal or emergency power source and complete isolation of associated ATS, independent of ATS operating position. BP/IS and associated ATS shall be products of same manufacturer and shall be completely interconnected and tested at factory and at project site as specified. BP/IS shall be manufactured, listed, and tested in accordance with paragraph AUTOMATIC TRANSFER SWITCH (ATS) and shall have electrical ratings that exceed or equal comparable ratings specified for ATS. Operating handles shall be externally operated and arranged so that one person can perform the bypass and isolation functions through the operation of a maximum of two handles within 5 seconds. The ATS shall have provisions for locking in the isolation position. Handle for manual operation shall be permanently attached to operating mechanism. BP/IS operation shall be accomplished without disconnecting switch load terminal conductors. Isolation handle positions shall be marked with engraved plates or other approved means to indicate position or operating condition of associated ATS, as follows:

a. Indication shall be provided to show that ATS section is providing power to the load.

b. Indication shall be provided of ATS isolation. The ATS controls shall remain functional with the ATS isolated or in bypass mode to permit monitoring of the normal power source. In the isolated mode, the bypass section shall be capable of functioning as a manual transfer switch to transfer the load to either power source. The ATS shall be capable of undergoing functional operation testing without service interruption. The ATS may also be completely removed from the enclosure, if required for maintenance or repair, while the bypass section continues to power the load.

2.2.2 Switch Construction

Bypass/isolation switch shall be constructed for convenient removal of parts from front of switch enclosure without removal of other parts or disconnection of external power conductors. Contacts shall be as specified for associated ATS, including provisions for inspection of contacts without disassembly of BP/IS or removal of entire contact enclosure. To facilitate maintenance, manufacturer shall provide instructions for determination of contact integrity. BP/IS and associated ATS shall be interconnected with suitably sized copper bus bars silver-plated at each connection point, and braced to withstand magnetic and thermal forces created at WCR specified for associated ATS.

2.3 ENCLOSURE

ATS and accessories shall be installed in free-standing, floor-mounted, ventilated NEMA ICS 6, Type 1, smooth sheet metal enclosure constructed in accordance with applicable requirements of UL 1066 and/or UL 1008. Intake vent shall be screened and filtered. Exhaust vent shall be screened. Door shall have suitable hinges, locking handle latch, and gasketed jamb. Metal gauge shall be not less than No. 14. Enclosure shall be equipped with at least two approved grounding lugs for grounding enclosure to facility ground system using No. 4 AWG copper conductors. Factory wiring within enclosure and field wiring terminating within enclosure shall comply with NFPA 70. If wiring is not color coded, wire shall be permanently tagged or marked near terminal at each end with wire number shown on approved detail drawing. Terminal block shall conform to NEMA ICS 4. Terminals shall be arranged for entrance of external conductors from top and bottom of enclosure as shown. Main switch terminals, including neutral terminal if used, shall be pressure type suitable for termination of external copper conductors shown.

2.3.1 Construction

Enclosure shall be constructed for ease of removal and replacement of ATS components and control devices from front without disconnection of external power conductors or removal or disassembly of major components. Enclosure of ATS with BP/IS shall be constructed to protect personnel from energized BP/IS components during ATS maintenance.

2.3.2 Cleaning and Painting

Both the inside and outside surfaces of an enclosure, including means for fastening, shall be protected against corrosion by enameling, galvanizing, plating, powder coating, or other equivalent means. Protection is not required for metal parts that are inherently resistant to corrosion, bearings, sliding surfaces of hinges, or other parts where such protection is impractical. Finish shall be manufacturer's standard material, process, and color and shall be free from runs, sags, peeling, or other defects. An

enclosure marked Type 1, 3R, 4 or 12 shall be acceptable if there is no visible rust at the conclusion of a salt spray (fog) test using the test method in ASTM B 117, employing a 5 percent by weight, salt solution for 24 hours. Type 4X enclosures are acceptable following performance of the above test with an exposure time of 200 hours.

2.4 TESTING

2.4.1 Factory Testing

A prototype of specified ATS shall be factory tested in accordance with UL 1008. In addition, factory tests shall be performed on each ATS as follows:

a. Insulation resistance test to ensure integrity and continuity of entire system.

b. Main switch contact resistance test.

c. Visual inspection to verify that each ATS is as specified.

d. Mechanical test to verify that ATS sections are free of mechanical hindrances.

e. Electrical tests to verify complete system electrical operation and to set up time delays and voltage sensing settings.

2.4.2 Factory Test Reports

Manufacturer shall provide three certified copies of factory test reports.

2.5 FACTORY TESTING

The factory tests for ATS and By-Pass/Isolation switches shall be conducted in the following sequence:

a. General
b. Normal
c. Overvoltage
d. Undervoltage
e. Overload
f. Endurance
g. Temperature Rise
h. Dielectric Voltage-Withstand
i. Contact Opening
j. Dielectric Voltage-Withstand (Repeated)
k. Withstand
l. Instrumentation and Calibration of High Capacity
m. Closing
n. Dielectric Voltage-Withstand (Repeated)
o. Strength of Insulating Base and Support

2.5.1 Viewing Ports

ATS and BP/IS switches shall be of draw-out construction. Viewing ports to inspect the contacts without requiring disassembly shall be provided.

2.5.2 Operating Handles

The operating handles shall be externally operated, and designed and constructed not to stop in an intermediate or neutral position during operation, but shall permit load by-pass and transfer switch isolation in no more than two manual operations which can be performed by one person in 5 seconds or less. The transfer speed will be independent of the operational speed of the switch handle or handles.

PART 3 EXECUTION

3.1 INSTALLATION

ATS shall be installed as shown and in accordance with approved manufacturer's instructions.

3.2 INSTRUCTIONS

Manufacturer's approved operating instructions shall be permanently secured to cabinet where operator can see them. One-line and elementary or schematic diagram shall be permanently secured to inside of front enclosure door.

3.3 SITE TESTING

Following completion of ATS installation and after making proper adjustments and settings, site tests shall be performed in accordance with manufacturer's written instructions to demonstrate that each ATS functions satisfactorily and as specified. Contractor shall advise Contracting Officer not less than 5 working days prior to scheduled date for site testing, and shall provide certified field test reports within 2 calendar weeks following successful completion of site tests. Test reports shall describe adjustments and settings made and site tests performed. Minimum operational tests shall include the following:

a. Insulation resistance shall be tested, both phase-to-phase and phase-to-ground.

b. Power failure of normal source shall be simulated by opening upstream protective device. This test shall be performed a minimum of five times.

c. Power failure of emergency source with normal source available shall be simulated by opening upstream protective device for emergency source. This test shall be performed a minimum of five times.

d. Low phase-to-ground voltage shall be simulated for each phase of normal source.

e. Operation and settings shall be verified for specified ATS features, such as override time delay, transfer time delay, return time delay, engine shutdown time delay, exerciser, auxiliary contacts, and supplemental features.

f. Manual and automatic ATS and BP/IS functions shall be verified.

-- End of Section --

SECTION 16442
SWITCHBOARDS AND SWITCHGEAR
07/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A 123/A 123M (2002) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A 153/A 153M (2005) Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM A 653/A 653M (2004a) Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASTM A 780 (2001) Repair of Damaged and Uncoated Areas of Hot-Dipped Galvanized Coatings

ASTM D 1535 (2001) Specifying Color by the Munsell System

ASTM D 709 (2001) Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2 (2005) National Electrical Safety Code

IEEE C37.13 (1990; R 1995) Low-Voltage AC Power Circuit Breakers Used in Enclosures

IEEE C37.20.1 (2002) Metal-Enclosed Low-Voltage Power Circuit-Breaker Switchgear

IEEE C37.90.1 (2002) Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

IEEE Std 100 (2000) The Authoritave Dictionary of IEEE Standards Terms

IEEE Std 81 (1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (Part 1)Normal Measurements

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS (2003) Acceptance Testing Specifications

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA C12.1	(2001) Code for Electricity Metering
NEMA C57.12.28	(1999) Pad-Mounted Equipment - Enclosure Integrity
NEMA ICS 6	(1993; R 2001) Industrial Control and Systems: Enclosures
NEMA PB 2	(2006) Deadfront Distribution Switchboards
NEMA PB 2.1	(1996) General Instructions for Proper Handling, Installation, Operation and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less
NEMA SG 5	(1995) Standard for Power Switchgear Assemblies

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2005) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 1558	(1999; Rev thru Mar 2006) Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
UL 198C	(1986; Rev thru Feb 1998)High-Interrupting-Capacity Fuses, Current-Limiting Types
UL 467	(2004) Grounding and Bonding Equipment
UL 489	(2002; Rev thru May 2003) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
UL 512	(1993; Rev thru Mar 1999) Fuseholders
UL 891	(2005) Dead-Front Switchboards

1.2 RELATED REQUIREMENTS

Section 16081 APPARATUS INSPECTION AND TESTING applies to this section, with the additions and modifications specified herein.

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE Std 100.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation;

submittals not having a "G" designation are for information only. Submit the following in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Switchboard and Switchgear Drawings

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Submittals shall include the nameplate data, size, and capacity. Submittals shall also include applicable federal, military, industry, and technical society publication references.

SD-03 Product Data

Switchboard and Switchgear; G

SD-06 Test Reports

Switchboard and Switchgear design tests; G

Switchboard and Switchgear production tests; G

Acceptance checks and tests; G

SD-10 Operation and Maintenance Data

Switchboard and Switchgear Operation and Maintenance, Data Package ; G

SD-11 Closeout Submittals

Assembled Operation and Maintenance Manuals

Equipment Test Schedule

Request for Settings

1.5 QUALITY ASSURANCE

1.5.1 Switchboard and Switchgear Product Data

Each submittal shall include manufacturer's information for each component, device and accessory provided with the switchboard and switchgear including:

a. Circuit breaker type, interrupting rating, and trip devices, including available settings

b. Manufacturer's instruction manuals and published time-current curves (on full size logarithmic paper) of the main secondary breaker and largest secondary feeder device.

1.5.2 Switchboard and Switchgear Drawings

Drawings shall include, but are not limited to the following:

a. One-line diagram including breakers, fuses, current transformers, and meters

b. Outline drawings including front elevation, section views, footprint, and overall dimensions

c. Bus configuration including dimensions and ampere ratings of bus bars

d. Markings and NEMA nameplate data, including fuse information (manufacturer's name, catalog number, and ratings)

e. Circuit breaker type, interrupting rating, and trip devices, including available settings

f. Three-line diagrams and elementary diagrams and wiring diagrams with terminals identified, and indicating prewired interconnections between items of equipment and the interconnection between the items.

g. Manufacturer's instruction manuals and published time-current curves (on full size logarithmic paper) of the main secondary breaker and largest secondary feeder device. These shall be used by the designer of record to provide breaker settings that will ensure protection and coordination are achieved.

h. Provisions for future extension.

i. Location and characteristics of spare devices, provisioned spaces, and space for installation of future equipment. Provisioned spaces shall be fully equiped spaces missing only the draw out circuit breaker.

1.5.2 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.5.3 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.4.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.4.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.6 MAINTENANCE

1.6.1 Switchboard and Switchgear Operation and Maintenance Data

Submit Operation and Maintenance Manuals in accordance with Section 01781 OPERATION AND MAINTENANCE DATA.

1.6.2 Assembled Operation and Maintenance Manuals

Manuals shall be assembled and bound securely in durable, hard covered, water resistant binders. The manuals shall be assembled and indexed in the following order with a table of contents. The contents of the assembled operation and maintenance manuals shall be as follows:

a. Manufacturer's O&M information required by the paragraph entitled "SD-10, Operation and Maintenance Data".

b. Catalog data required by the paragraph entitled, "SD-03, Product Data".

c. Drawings required by the paragraph entitled, "SD-02, Shop Drawings".

d. Spare parts and supply list.

e. Information on metering

f. Design test reports

1.7 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

Products and materials not considered to be switchboards or switchgear and related accessories are specified in Section 16302 UNDERGROUND ELECTRICAL DISTRIBUTION or Section 16402 INTERIOR DISTRIBUTION SYSTEM.

2.2 SWITCHBOARD and SWITCHGEAR

Switchboard: NEMA PB 2 and Switchgear: UL 891 and IEEE C37.20.1 and UL 1558.

2.2.1 Ratings

The voltage rating of the switchboard and switchgear shall be as indicated. The continuous current rating of the main bus shall be as indicated. The short-circuit current rating shall be as indicated but not less then 36,000 ampereres. The switchboard and switchgear shall be UL listed and labeled for its intended use.

2.2.2 Construction

a. Switchboard shall consist of dead-front type vertical sections bolted together to form a rigid assembly and shall be front and rear aligned. Switchgear construction shall be dead front, metal enclosed low voltage siwtchgear, and conform to the applicable portions of IEEE C37.20.1, NEMA SG 5, and be UL 1558 listed. All circuit breakers shall be front accessible. Rear aligned switchboards shall have front accessible load connections. Compartmentalized switchboards and switchgear shall have vertical insulating barriers between the front device section, the main bus section, and the cable compartment with full front to rear vertical insulating barriers between adjacent sections. Where indicated, "space for future" or "space" shall mean to include bus, device supports, and connections. Provide insulating barriers in accordance with NEMA LI 1, Type GPO-3, 0.25 inch minimum thickness. Apply moisture resistant coating to all rough-cut edges of barriers. Switchboard shall be completely factory engineered and assembled, including protective devices and equipment indicated with necessary interconnections, instrumentation, and control wiring

b. Each vertical steel unit forming part of the low voltage switchgear line-up shall be a self-contained housing having one or more individual circuit breaker or instrument compartments, a centralized bus compartment and a rear-cabling compartment. Each individual circuit breaker compartment, or cell, shall be completely segregated from adjacent compartments or sections by means of steel barriers at the rear, top, bottom and sides. Each cell shall be equipped with drawout rails and primary and secondary disconnecting contacts. Current transformers for feeder instrumentation shall be located within the appropriate circuit breaker cells.

c. Provide insulated copper load bus extensions terminating in solderless type terminals in the ear cable compartment in each structure. The secondary disconnecting devices shall be silver-plated with sliding contact arrangement and shall only engage in the connected and test positions.

d. A polyester insulating flash shiedl shall be mounted on the ceiling of each breker cell to protect the operator by preventing flashover for the arc chutes to ground.

e. Provide remote racking of drawout circuit breaker via a proramable device specifically designed for hte switchgear.

f. Provide grounded steel shutters which operate to cover the cell line and load side connections when the circuit breaker element is withdrawn.

2.2.2.1 Enclosure

The switchboard and switchgear enclosure shall be a NEMA ICS 6 Type 1. Enclosure shall be bolted together with removable bolt-on side and hinged rear covers. Front and rear doors shall be provided with padlockable vault handles with a three point catch. Bases, frames and channels of enclosure shall be corrosion resistant and shall be fabricated of galvanized steel. Base shall include any part of enclosure that is within 3 inches of concrete pad. Galvanized steel shall be ASTM A 123/A 123M, ASTM A 653/A 653M G90 coating, and ASTM A 153/A 153M, as applicable. Galvanize after fabrication where practicable. Paint enclosure, including bases, ASTM D 1535 light gray No. 61 or No. 49. Paint coating system shall comply with NEMA C57.12.28 for galvanized steel. Outdoor switchgear shall be “walk-in” construction. Such switchgear shall include thermostatic controlled equipment space heaters and aisle space heaters. The assemble shall be provided with adequate lifting means to be moved into position and mounted direction the concrete pad provided by others.

2.2.2.2 Bus Bars

Bus bars shall be copper with silver-plated contact surfaces. Plating shall be a minimum of 0.0002 inch thick. Make bus connections and joints with hardened steel bolts. The through-bus shall be rated at the full ampacity of the main throughout the switchboard. Provide minimum one-quarter by 2 inch copper ground bus secured to each vertical section along the entire length of the switchboard and switchgear. The neutral bus shall be rated 100 percent of the main bus continuous current rating. Supports and bus bracing shall be of adequate strength for the rated fault current and in excess of the calculated available fault current.

2.2.2.3 Main Section

The main section shall consist of an individually mounted drawout air power circuit breaker for switchgear and an individually mounted molded case circuit breaker for switchboards.

2.2.2.4 Distribution Sections

The distribution sections shall consist of individually mounted, drawout, air power circuit breakers as indicated.

2.2.2.5 Auxiliary Sections

Auxiliary sections shall be provided and house instruments, metering equipment, control power transformers, instrument transformers, and monitoring and control terminations as indicated.

2.2.2.6 Handles

Handles for individually mounted devices shall be of the same design and method of external operation. Label handles prominently to indicate device ampere rating, color coded for device type. Identify ON-OFF indication by handle position and by prominent marking.

2.2.3 Protective Device

Provide main and branch protective devices as indicated.

2.2.3.1 Power Circuit Breaker

IEEE C37.13. 120 Vac electrically manually operated drawout, unfused low-voltage power circuit breaker with a short-circuit current rating as indicated at 480 volts for switchgear and an individually mounted molded case circuit breaker for switchboards. Breaker frame size shall be as indicated. Equip electrically operated breakers with motor-charged, stored-energy closing mechanism to permit rapid and safe closing of the breaker against fault currents within the short time rating of the breaker, independent of the operator's strength or effort in closing the handle.

2.2.3.2 Molded-Case Circuit Breaker

UL 489. UL listed and labeled, 100 percent rated, stationary with mountred. adjustable trip elements,, electrically operated, low voltage molded-case circuit breaker, with a short-circuit current rating of as indicated at 480 volts. Breaker frame size shall be as indicated. Series rated circuit breakers are unacceptable.

2.2.3.3 Fusible Switches

Fusible Switches: Quick-make, quick-break, hinged-door type. Switches serving as motor disconnects shall be horsepower rated. Fuses shall be current-limiting cartridge type conforming to UL 198C, Class J for 0 to 600 amperes and Class L for 601 to 6000 amperes.

Fuseholders: UL 512.

2.2.4 Drawout Breakers

Equip drawout breakers with disconnecting contacts, wheels, and interlocks for drawout application. The main, auxiliary, and control disconnecting contacts shall be silver-plated, multifinger, positive pressure, self-aligning type. Each drawout breaker shall be provided with four-position operation. Each position shall be clearly identified by an indicator on the circuit breaker front panel. Each circuit breaker shall have Mechanism Operated Contacts (MOCS) and Truck Operated Contacts (TOCS) cell mounted switch assemblies for control monitoring and interlocking. All draw out circuit breakers shall be electrically trip/close operated from local and remote locations.

2.2.4.1 Connected Position

Cell switches may be connected either in parallel or in series with control contacts that are used for interlocking, but either connection shall permit operation of a circuit breaker when it is in a test position. In addition to any contacts used or shown, each circuit breaker shall be provided with four spare auxiliary and cell contacts, two normally open and two normally closed, wired to interconnection terminals. If auxiliary relays are used to provide additional contacts, such relays shall not be of the latching type. Interconnection terminal blocks shall be wired to permit remote open and close operations of each circuit breaker and for other required exterior connections or connections between switchgear sections.

Primary and secondary contacts are fully engaged. Breaker must be tripped before racking into or out of position.

2.2.4.2 Test Position

Primary contacts are disconnected but secondary contacts remain fully engaged. Position shall allow complete test and operation of the breaker without energizing the primary circuit. Closed door drawout capability shall be provided to allow breaker to be in the test of disconnect position with the door closed.

2.2.4.3 Disconnected Position

Primary and secondary contacts are disconnected.

2.2.4.4 Withdrawn (Removed) Position

Places breaker completely out of compartment, ready for removal. Removal of the breaker shall actuate assembly that isolates the primary stabs.

2.2.4.4.1 Lock Out Tag Out

All panelboards and switchboards shall be provided with a readily available Lock-out/Tag-out system. The system shall provide the operator with all the equipment necessary to Lock-out/Tag-out at the panelboard or switchboard except for a standard lock.

2.2.5 Adjustable Electronic Trip Units

Equip main and distribution breakers with a solid-state tripping system consisting of three current sensors and a microprocessor-based trip unit that will provide true rms sensing adjustable time-current circuit protection. The ampere rating of the current sensors shall be as indicated. The trip unit ampere rating shall be as indicated. Ground fault protection shall be zero sequence sensing. The electronic trip units shall have the following features.

a. Breakers shall have long delay pick-up and time settings, and LED indication of cause of circuit breaker trip.

b. Main, tie, and feeder breakers shall have short delay pick-up and time settings and ground fault settings.

c. Main Breakers shall have a digital display for phase and ground current.

d. Main Breakers shall have a digital display for watts, vars, VA, kWh, kvarh, and kVAh.

e. Main Breakers shall have a digital display for phase voltage, and percent THD voltage and current.

f. Main Breakers shall have provisions for communication via a network twisted pair cable for remote monitoring and control.

g. All brekes shall be equiped with status and permissve indcating lights for indication only.

h. Critical breaker interlocks shall be fail safe and not dependantant upon an operator for successful operation

2.2.6 Electrical Indicating Instruments

Electrical instrumentation devices shall be compatible as a system, sealed, dust and water tight, utilize modular components with metal housings and digital instrumentation. Date display shall utilize LED or back-lit LCD. Numeral height shall be 1/2 inch.2.2.6.1 Multifunction Digital Metering Unit UL listed or recognized microprocessor-based unit suitable for three- or four-wire systems and with the following features:

a. Inputs and Ranging: From sensors or current transformers from 50/5 through 6000/5 ratings and voltage sensing terminals capable of directly accepting up to 600 volts, and scaled 120 volt input from voltage transformers of up to 1000:1 ratio.

b. Data holding: Unit shall continue to accumulate and retain data for control power outages up to one week in duration.

c. Display: Switch selectable digital display allowing display of the following values with maximum accuracy tolerances as indicated:

Multifunction Digital Metering Unit

Parameter	Accuracy	Notes
Each Phase Current	Plus or minus 1 percent, plus or minus 1 digit	Provide ability to display minimum and maximum values since last reset.
Average Phase Current	Plus or minus 1 percent, plus or minus 1 digit	
Phase-to-Phase Voltages	Plus or minus 1 percent, plus or minus 1 digit	Provide ability to display minimum and maximum values since last reset.
Each Phase-to-Neutral Voltage	Plus or minus 1 percent, PLUS OR MINUS 1 digit	
Real Power	Plus or minus 1 percent, plus or minus 1 digit	Provide ability to display minimum and maximum values since last reset and ability to display kilowatts or megawatts
Reactive Power	Plus or minus 1 percent, plus or minus 1 digit	Provide ability to display minimum and maximum values since last reset and ability to display kilovars or megavars
Accumulated Energy	Plus or minus 1/2 percent, plus or minus 1 digit	Provide ability to display minimum and maximum values since last reset and

Multifunction Digital Metering Unit

		ability to display kilowatts or megawatts
Real Demand	Plus or minus 1 percent, plus or minus 1 digit	Provide ability to display kilowatts or megawatts. Demand interval shall be programmable from 5 minutes to one hour, with the ability to select a fixed or sliding-window demand interval.
Harmonic Current and Harmonic Voltage	Plus or minus 2 percent, plus or minus 1 digit	Display total harmonic distortion for Current and voltage with ability to display minimum and maximum values since last reset. Calculate up to the 39th harmonic.
Power Factor	Plus or minus 2 percent, plus or minus 1 digit	Provide ability to display minimum and maximum values since last reset.
Frequency	Plus or minus 0.1 percent, plus or minus 1 digit	Provide ability to display minimum and maximum values since last reset.

d. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

e. Digital metering units shall be SCADA compatible and contain the necessary communiction ports for connection to the SCADA system. Coordinate with the SCADA providers.

2.2.7 Test Blocks and Accessories

Test blocks and their associated testing accessories shall be provided for testing of instruments and protective relays that require periodic testing or calibration in-place, but which are not equipped with integral testing features. Test blocks with covers shall be mounted near the base of the switchgear unit beneath the devices to be tested, and shall be provided with a nameplate engraved to identify individual current or potential test blocks, or a combination current/potential test block, as applicable. Combination test blocks shall not exceed 10 poles. Current test blocks shall be the short-circuiting type.

2.2.8 Watthour and Digital Meters

2.2.8.1 Digital Meters

IEEE C37.90.1 for surge withstand. Provide true rms, plus/minus one percent accuracy, programmable, microprocessor-based meter enclosed in sealed cases with a simultaneous three line, twelve value LED display.

Meters shall have 0.56 inch, minimum, LEDs.

2.2.9 Current Transformers

Ratios as indicated and accuracy class of 0.3 with burden as required for connected relays, meters, instruments and test blocks, plus an additional burden of 0.25 ohm. Current transformers used for metering shall also have a rating factor of 2.0 or greater. Current transformers for bus differential protection shall be C200 class.

2.2.10 Meter Fusing

Provide a fuse block mounted in the metering compartment containing one fuse per phase to protect the voltage input to voltage sensing meters. Size fuses as recommended by the meter manufacturer.

2.2.11 Terminal Boards

Provide with engraved plastic terminal strips and screw type terminals for external wiring between components and for internal wiring between removable assemblies. Terminal boards associated with current transformers shall be short-circuiting type. Terminate conductors for current transformers with ring-tongue lugs. Terminal board identification shall be identical in similar units.

2.2.12 Wire Marking

Mark control and metering conductors at each end. Provide factory-installed, white, plastic tubing, heat stamped with black block type letters on factory-installed wiring. On field-installed wiring, provide white, preprinted, polyvinyl chloride (PVC) sleeves, heat stamped with black block type letters. Each sleeve shall contain a single letter or number, shall be elliptically shaped to securely grip the wire, and shall be keyed in such a manner to ensure alignment with adjacent sleeves. Provide specific wire markings using the appropriate combination of individual sleeves. Each wire marker shall indicate the device or equipment, including specific terminal number to which the remote end of the wire is attached.

2.3 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable. This nameplate and method of attachment may be the manufacturer's standard if it contains the required information.

2.4 FIELD FABRICATED NAMEPLATES

ASTM D 709. Provide laminated plastic nameplates for each switchboard, and switchgear, equipment enclosure, relay, switch, and device; as specified in this section or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 0.125 inch thick, white with center core. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be one by 2.5 inches. Lettering shall be a minimum of 0.25 inch high normal block style.

2.5 SOURCE QUALITY CONTROL

2.5.1 Equipment Test Schedule

The Government reserves the right to witness tests. Provide equipment test schedules for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 30 calendar days before scheduled test date. Notify Contracting Officer 15 calendar days in advance of changes to scheduled date.

a. Test Instrument Calibration

1. The manufacturer shall have a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

2. The accuracy shall be directly traceable to the National Institute of Standards and Technology.

3. Instrument calibration frequency schedule shall not exceed 12 months for both test floor instruments and leased specialty equipment.

4. Dated calibration labels shall be visible on all test equipment.

5. Calibrating standard shall be of higher accuracy than that of the instrument tested.

6. Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:

(a) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

(b) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

2.5.2 Switchboard and Switchgear Design Tests

Switchboards - NEMA PB 2; Switchgear - UL 891, IEEE C37.20.1 and UL 1558.

2.5.2.1 Design Tests

Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this specification.

a. Short-circuit current test
b. Enclosure tests
c. Dielectric test

2.5.2.2 Additional design tests

In addition to normal design tests, perform the following tests on the actual equipment. Furnish reports which include results of design tests performed on the actual equipment.

a. Temperature rise tests
b. Continuous current

2.5.3 Switchboard and Switchgear Production Tests

Switchboards - NEMA PB 2; Switchgear - UL 891, IEEE C37.20.1 and UL 1558. Furnish reports which include results of production tests performed on the actual equipment for this project. These tests include:

a. 60-hertz dielectric tests
b. Mechanical operation tests
c. Electrical operation and control wiring tests
d. Ground fault sensing equipment test

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations shall conform to IEEE C2, NFPA 70, and to the requirements specified herein.

3.2 GROUNDING

NFPA 70 and IEEE C2, except that grounds and grounding systems shall have a resistance to solid earth ground not exceeding 3 ohms..

3.2.1 Grounding Electrodes

Provide driven ground rods as specified in Section 16302 UNDERGROUND ELECTRICAL DISTRIBUTION. Connect ground conductors to the upper end of the ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.2.2 Equipment Grounding

Provide bare copper cable not smaller than No. 4/0 AWG not less than 24 inches below grade connecting to the indicated ground rods. When work in addition to that indicated or specified is directed to obtain the specified ground resistance, the provision of the contract covering "Changes" shall apply.

3.2.3 Connections

Make joints in grounding conductors and loops by exothermic weld or compression connector. Exothermic welds and compression connectors shall be installed as specified inSection 16302 UNDERGROUNDELECTRICAL DISTRIBUTION.

3.2.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect equipment furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.3.1 Switchboard

NEMA PB 2.1.

3.3.2 Switchgear

IEEE C37.20.1.

3.3.3 Meters and Instrument Transformers

NEMA C12.1.

3.3.4 Field Applied Painting

Where field painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's instructions.

3.3.5 Galvanizing Repair

Repair damage to galvanized coatings using ASTM A 780, zinc rich paint, for galvanizing damaged by handling, transporting, cutting, welding, or bolting. Do not heat surfaces that repair paint has been applied to.

3.3.6 Field Fabricated Nameplate Mounting

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.4 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

3.4.1 Interior Location

Mount switchboard and switchgear on concrete slab. Unless otherwise indicated, the slab shall be at least 4 inches thick. The top of the concrete slab shall be approximately 4 inches above finished floor. Edges above floor shall have 1/2 inch chamfer. The slab shall be of adequate size to project at least 8 inches beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 3 inches above slab surface. Concrete work shall be as specified in Section 03300 CAST-IN-PLACE CONCRETE.

3.5 FIELD QUALITY CONTROL

Contractor shall submit request for settings of breakers to the Contracting Officer after approval of switchboard and switchgear and at least 30 days in advance of their requirement.

3.5.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.5.1.1 Switchboard Assemblies

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical, electrical, and mechanical condition.

3. Confirm correct application of manufacturer's recommended lubricants.

4. Verify appropriate anchorage, required area clearances, and correct alignment.

5. Inspect all doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.

6. Verify that circuit breaker sizes and types correspond to approved shop drawings.

7. Verify that current transformer ratios correspond to approved shop drawings.

8. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

9. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

10. Clean switchboard.

11. Inspect insulators for evidence of physical damage or contaminated surfaces.

12. Verify correct barrier and shutter installation and operation.

13. Exercise all active components.

14. Inspect all mechanical indicating devices for correct operation.

15. Verify that vents are clear.

16. Test operation, alignment, and penetration of instrument transformer withdrawal disconnects.

17. Inspect control power transformers.

b. Electrical Tests

1. Perform insulation-resistance tests on each bus section.

2. Perform overpotential tests.

3. Perform insulation-resistance test on control wiring; Do not

perform this test on wiring connected to solid-state components.

4. Perform control wiring performance test.

5. Perform primary current injection tests on the entire current circuit in each section of assembly.

3.5.1.2 Switchgear

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical, electrical, and mechanical condition.

3. Confirm correct application of manufacturer's recommended lubricants.

4. Verify appropriate anchorage, required area clearances, and correct alignment.

5. Inspect all doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.

6. Verify that fuse and circuit breaker sizes and types correspond to approved shop drawings.

7. Verify that current transformer ratios correspond to approved shop drawings.

8. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

9. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

10. Clean switchgear.

11. Inspect insulators for evidence of physical damage or contaminated surfaces.

12. Verify correct barrier and shutter installation and operation.

13. Exercise all active components.

14. Inspect all mechanical indicating devices for correct operation.

15. Verify that vents are clear.

16. Test operation, alignment, and penetration of instrument transformer withdrawal disconnects.

17. Inspect control power transformers.

b. Electrical Tests

1. Perform insulation-resistance tests on each bus section.

2. Perform overpotential tests.

3. Perform insulation-resistance test on control wiring; Do not perform this test on wiring connected to solid-state components.

4.Perform control wiring performance test.

5. Perform primary current injection tests on the entire current circuit in each section of assembly.

6. Perform phasing check on double-ended switchgear to ensure correct bus phasing from each source.

2.5.1.3 Circuit Breakers - Low Voltage – Power

a. Visual and Mechanical Inspection

1. Compare nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Confirm correct application of manufacturer's recommended lubricants.

4. Inspect anchorage, alignment, and grounding. Inspect arc chutes. Inspect moving and stationary contacts for condition, wear, and alignment.

5. Verify that all maintenance devices are available for servicing and operating the breaker.

6. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.

7. Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism.

8. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

9. Verify cell fit and element alignment.

10. Verify racking mechanism.

b. Electrical Tests

1. Perform contact-resistance tests on each breaker.

2. Perform insulation-resistance tests.

3. Adjust Breaker(s) for final settings in accordance with Government provided settings.

4. Determine long-time minimum pickup current by primary current injection.

5. Determine long-time delay by primary current injection.

6. Determine short-time pickup and delay by primary current injection.

7. Determine ground-fault pickup and delay by primary current injection.

8. Determine instantaneous pickup value by primary current injection.

9. Activate auxiliary protective devices, such as ground-fault or undervoltage relays, to ensure operation of shunt trip devices; Check the operation of electrically-operated breakers in their cubicle.

10. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and antipump function.

11. Verify operation of charging mechanism.

3.5.1.3 Circuit Breakers

Low Voltage Molded Case with Solid State Trips

a. Visual and Mechanical Inspection

1. Compare nameplate data with specifications and approved shop drawings.

2.Inspect circuit breaker for correct mounting.

3. Operate circuit breaker to ensure smooth operation.

4. Inspect case for cracks or other defects.

5. Inspect all bolted electrical connections for high resistance using low resistance ohmmeter, verifying tightness of accessible bolted connections and/or cable connections by calibrated torque-wrench method, or performing thermographic survey.

6. Inspect mechanism contacts and arc chutes in unsealed units.

b. Electrical Tests

1. Perform contact-resistance tests.

2. Perform insulation-resistance tests.

3. Perform Breaker adjustments for final settings in accordance with Government provided settings.

4. Perform long-time delay time-current characteristic tests

5. Determine short-time pickup and delay by primary current injection.

6. Determine ground-fault pickup and time delay by primary current injection.

7. Determine instantaneous pickup current by primary injection.

8. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and anti-pump function.

3.5.1.4 Current Transformers

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Verify correct connection.

4. Verify that adequate clearances exist between primary and secondary circuit.

5. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

6. Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests

1. Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

3. Perform insulation-resistance tests.

4. Perform polarity tests.

5. Perform ratio-verification tests.

2.5.1.6 Metering and Instrumentation

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Verify tightness of electrical connections.

b. Electrical Tests

1. Determine accuracy of meters at 25, 50, 75, and 100 percent of full scale.

2. Calibrate watthour meters according to manufacturer's published data.

3. Verify all instrument multipliers.

4. Electrically confirm that current transformer and voltage transformer secondary circuits are intact.

3.5.1.7 Grounding System

a. Visual and Mechanical Inspection

1. Inspect ground system for compliance with contract plans and specifications.

b. Electrical Tests

1. IEEE Std 81. Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground testing megger in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument shall be equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

2. Submit the measured ground resistance of each ground subsystem and grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (i.e., pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

3.5.2 Follow-Up Verification

Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Circuit breakers shall be tripped by operation of each protective device. Test shall require each item to perform its function not less than three times. As an exception to requirements stated elsewhere in the contract, the Contracting Officer shall be given 5 working days advance notice of the dates and times for checks, settings, and tests.

-- End of Section --

SECTION 16475
COORDINATED POWER SYSTEM PROTECTION
04/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.11	(1987) Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV)
ANSI C37.06	(2000) AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis - Preferred Ratings and Related Required Capabilities
ANSI C37.16	(2000) Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors - Preferred Ratings, Related Requirements, and Application Recommendations
ANSI C37.46	(2000) For High Voltage Expulsion and Current-Limiting Type Power Class Fuses and Fuse Disconnecting Switches
ANSI C37.50	(1989; R 2000) Low-Voltage AC Power Circuit Breakers Used in Enclosures - Test Procedures

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2005) National Electrical Safety Code
IEEE C37.04	(1999) Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
IEEE C37.13	(1990; R 1995) Low-Voltage AC Power Circuit Breakers Used in Enclosures
IEEE C37.2	(1996) Electrical Power System Device Function Numbers and Contact Designations
IEEE C37.20.1	(2002) Metal-Enclosed Low-Voltage Power Circuit-Breaker Switchgear
IEEE C37.90	(1994) Relays and Relay Systems Associated with Electric Power Apparatus

IEEE C57.13	(1993; R 2003) Standard Requirements for Instrument Transformers
IEEE Std 242	(2001) Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems - Buff Book
IEEE Std 399	(1997) Recommended Practice for Power Systems Analysis - Brown Book

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA AB 1	(2002) Molded-Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures
NEMA FU 1	(2002) Low Voltage Cartridge Fuses
NEMA ICS 1	(2000; R 2005) Industrial Control and Systems: General Requirements
NEMA ICS 2	(1996; R 2004) Standard for Industrial Control and Systems: Controllers, Contractors, and Overload Relays Rated Not More than 2000 Volts AC or 750 Volts DC: Part 8 - Disconnect Devices for Use in Industrial Control Equipment
NEMA ICS 3	(2005) Industrial Control and Systems: Medium Voltage Controllers Rated 2001 to 7200 Volts AC
NEMA ICS 6	(1993; R 2001) Industrial Control and Systems: Enclosures
NEMA SG 2	(1993) High Voltage Fuses
NEMA SG 6	(2000) Power Switching Equipment

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2005) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 198B	(1995) Class H Fuses
UL 486E	(1994; Rev thru May 2000) Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors
UL 489	(2002; Rev thru May 2003) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
UL 508	(1999; Rev thru Dec 2003) Industrial Control Equipment
UL 845	(2005) Motor Control Centers

UL 877 (1993; Rev thru Nov 1999) Circuit Breakers and Circuit-Breaker Enclosures for Use in Hazardous (Classified) Locations

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Fault Current Analysis

Protective Device Coordination Study

The study along with protective device equipment submittals. No time extensions or similar contact modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed will be based on recommendations of this study. The Government shall not be held responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered and/or procured prior to approval of the study.

Equipment

Data consisting of manufacturer's time-current characteristic curves for individual protective devices, recommended settings of adjustable protective devices, and recommended ratings of non-adjustable protective devices.

System Coordinator

Verification of experience and license number, of a registered Professional Engineer with at least 3 years of current experience in the design of coordinated power system protection. Experience data shall include at least five references for work of a magnitude comparable to this contract, including points of contact, addresses and telephone numbers. This engineer must perform items required by this section to be performed by a registered Professional Engineer.

Protective Relays

Data shall including calibration and testing procedures and instructions pertaining to the frequency of calibration, inspection, adjustment, cleaning, and lubrication.

Installation

Procedures including diagrams, instructions, and precautions required to properly install, adjust, calibrate, and test the devices and equipment.

SD-06 Test Reports

Field Testing

The proposed test plan, prior to field tests. Plan shall consist of complete field test procedure including tests to be performed, test equipment required, and tolerance limits, including complete testing and verification of the ground fault protection equipment, where used. Performance test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report shall indicate the final position of controls.

SD-07 Certificates

Devices and Equipment

Certificates certifying that all devices or equipment meet the requirements of the contract documents.

1.3 QUALIFICATIONS

1.3.1 System Coordinator

System coordination, recommended ratings and settings of protective devices, and design analysis shall be accomplished by a registered professional electrical power engineer with a minimum of 3 years of current experience in the coordination of electrical power systems.

1.3.2 System Installer

Calibration, testing, adjustment, and placing into service of the protective devices shall be accomplished by a manufacturer's product field service engineer or independent testing company with a minimum of two years of current product experience in protective devices.

1.4 DELIVERY, STORAGE, AND HANDLING

Devices and equipment shall be visually inspected when received and prior to acceptance from conveyance. Stored items shall be protected from the environment in accordance with the manufacturer's published instructions. Damaged items shall be replaced.

1.5 PROJECT/SITE CONDITIONS

Devices and equipment furnished under this section shall be suitable for the following site conditions. Seismic details shall conform to Sections 13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT, 15070 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT, AND 16070 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

1.5.1 Altitude

Altitude: 1000 feet

1.5.2 Ambient Temperature

Ambient Temperature: -20 to +104 degrees F

1.5.3 Frequency

Frequency: 60 Hz

1.5.4 Fungus Control

Fungus Control: As required

1.5.5 Hazardous Classification

Hazardous Classification: Not applicable to this project

1.5.6 Humidity Control

Humidity Control: Not required

1.5.7 Ventilation

Ventilation: Natural circulation

1.5.8 Seismic Parameters

Seismic Parameters: Seismic use Group IIIC

PART 2 PRODUCTS

2.1 STANDARD PRODUCT

Protective devices and equipment shall be the standard product of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate items that have been in satisfactory utility type use for at least two years prior to bid opening.

2.2 NAMEPLATES

Nameplates shall be provided to identify all protective devices and equipment. Nameplate information shall be in accordance with NEMA AB 1 or NEMA SG 6 as applicable.

2.3 CORROSION PROTECTION

Metallic materials shall be protected against corrosion. Ferrous metal hardware shall be zinc or chrome-plated.

2.4 MOTOR CONTROLS AND MOTOR CONTROL CENTERS

Motor controls and motor control centers shall be in accordance with NEMA ICS 1, NEMA ICS 2, NEMA ICS 3 and NEMA ICS 6, and UL 508and UL 845.

2.4.1 Motor Starters

Combination starters shall be provided with circuit breakers.

2.4.1.1 Motor controllers shall have the following characteristics:

2.4.1.1.1 Coordinate the features of each motor controller with the ratings and characteristics of the supply circuit, the motor, the required control sequence and control circuit, the duty cycle of the motor, mechanical load, and the pilot device. Provide NEMA controllers that are horsepower rated to suit the motor controlled.

2.4.1.1.2 Contacts shall mechanically open each ungrounded connection to the motor by means of an air or vacuum gap.

2.4.1.1.3 Provide two spare normally open auxiliary contacts and two spare normally closed auxiliary contacts, in addition to those required for the control and interface connections for the particular controller.

2.4.1.1.4 Enhanced-Protection Overload Relay: Provide overload relays with NEMA Class 10 inverse-time tripping characteristics. Select to protect motor against ground fault and undervoltage as a minimum, and in accordance with the respective motor nameplate current. Provide ambient-compensated sensors in each phase matched to nameplate full-load current of the specific motor to which connected with appropriate adjustment for duty cycle.

2.4.1.1.5 Provide green pilot light to indicate motor stopped and red pilot light to indicate motor running. Pilot lights shall be Light Emitting Diode (LED) type, with a minimum intensity of 200 milli candelas, and a minimum life of 50,000 hours.

2.4.1.1.6 Provide enclosures suitable for the environmental conditions at the controller location. Provide NEMA Type 1 enclosures except where NEMA 3R or 4X is warranted.

2.4.1.1.7 Manual motor controllers shall be quick-make, quick-break toggle switch type with overload elements and pilot light.

2.4.1.1.8 Magnetic motor controllers shall be full-voltage, non-reversing, across-the-line, magnetic controller, except where another type is indicated.

2.4.1.1.9 Motor Start-Stop Control:

2.4.1.1.9.1 Provide control circuit arrangement suitable for 3 wire control.

2.4.1.1.9.2 Provide Hand-Off-Auto (HOA) selector switch connected to operate as follows:

2.4.1.1.9.3 Hand position: All control contacts, except for overloads and safety interlocks are bypassed and the motor contactor is energized.

2.4.1.1.9.4 Off position: The motor contactor is de-energized, and the motor is stopped. Neither local nor automatic control can start the motor with the HOA switch in the Off position

2.4.1.1.9.5 Auto position: Start-stop control of the motor is transferred to the external control circuit

2.4.1.1..10 Pushbutton stations, pilot lights, and selector switches shall be heavy-duty type.

2.4.1.1.11 Provide either AC or DC power supply and control power.

Provide control power supply for each motor controller connected to a circuit rated higher than 120 volts line to neutral or where no neutral is present. Both primary leads are to be fused. All fuses shall be current limiting rejection type mounted in a rejection type fuse holder that shall only accept current limiting fuses

2.4.1.1.11.1 AC control power supply: One lead shall be grounded and non-fused, and the other lead shall be fused. Open circuit voltage shall be no more than 120 volts AC.

2.4.1.1.11.2 DC control power supply: Secondary leads are allowed to be floating or one secondary lead may be grounded. All non-grounded secondary leads shall be fused. All fuses shall be current limiting rejection type mounted in a rejection type fuse holder that shall only accept current limiting fuses. Inherent current limiting circuitry that shall limit the DC short to 5 amperes is acceptable in lieu of fusing of the DC control power supply output circuit. Open circuit secondary voltage of control power supply is to be no more than 24 volts DC.

2.4.2 Reduced-Voltage Starters

Reduced-voltage starters shall be provided for polyphase motors 100 hp or larger. Reduced-voltage starters shall be of the single-step autotransformer, reactor, or resistor type having an adjustable time interval between application of reduced and full voltages to the motors. Wye-delta reduced voltage starter or part winding increment starters having an adjustable time delay between application of voltage to first and second winding of motor, may be used in lieu of the reduced voltage starters specified above for starting of motor-generator sets, centrifugally operated equipment or reciprocating compressors provided with automatic unloaders.

2.4.3 Thermal-Overload Protection

Each motor of 1/8 hp or larger shall be provided with thermal-overload protection. Polyphase motors shall have overload protection in each ungrounded conductor. The overload-protection device shall be provided either integral with the motor or controller, or shall be mounted in a separate enclosure. Unless otherwise specified, the protective device shall be of the manually reset type. Single or double pole tumbler switches specifically designed for alternating-current operation only may be used as manual controllers for single-phase motors having a current rating not in excess of 80 percent of the switch rating.

2.4.4 Low-Voltage Motor Overload Relays

2.4.4.1 General

Thermal overload relays shall conform to NEMA ICS 2 and UL 508. Overload protection shall be provided either integral with the motor or controller, and shall be rated in accordance with the requirements of NFPA 70. Standard units shall be used for motor starting times up to 7 second. Slow units shall be used for motor starting times from 8 to 12 seconds. Quick trip units shall be used on hermetically sealed, submersible pumps, and similar motors.

2.4.4.1.1 Solid-State Overload Relays

Solid State Overload Relay shall be used for to provide Motor overload protection.

a. Provide a solid-state overload relay for protection of the motors. The relay shall be Cutler-Hammer type CEP7 or approved equal.

b. The overload relay shall provide high accuracy through the use of state-of-the-art microelectronic packaging technology. The relay shall be suitable for application with NEMA Size 1 through Size 7 motor starters.

c. The overload relay shall be modular in design, be an integral part of a family of relays to provide a choice of levels of protection, be designed to directly replace existing electromechanical overload relays, and be listed under UL Standard 508.

d. The overload relay shall have the following features:

1. Be self-powered
2. Class 10 or 20 fixed tripping characteristics
3. Manual or automatic reset
4. Phase loss protection. The relay shall trip in 2 seconds or less under phase loss condition when applied to a fully loaded motor
5. Visible trip indication
6. One NO and one NC isolated auxiliary contact
7. Test button that operates the normally closed contact
8. Test trip function that trips both the NO and NC contacts
9. A current adjustment range of 3.2:1 or greater
10. Ambient temperature compensated
11. Ground fault protection. Relay shall trip at 50% of full load ampere setting
12. Jam/Stall protection. Relay shall trip at 400% of full load ampere setting, after inrush

2.4.4.2 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Trip current ratings shall be established by selection of the replaceable overload device or shall not be adjustable over the appropriate range. Where the controller is remotely-located or difficult to reach, an automatic reset, non-compensated overload relay shall be provided. Manual reset overload relays shall be provided otherwise, and at all locations where automatic starting is provided. Where the motor is located in a constant ambient temperature, and the thermal device is located in an ambient temperature that regularly varies by more than 14 degrees F, an ambient temperature-compensated overload relay shall be provided.

2.4.5 Automatic Control Devices

2.4.5.1 Direct Control

Automatic control devices (such as thermostats, float or pressure switches) which control the starting and stopping of motors directly shall be designed for that purpose and have an adequate horsepowerrating.

2.4.5.2 Pilot-Relay Control

Where the automatic-control device does not have such a rating, a magnetic starter shall be used, with the automatic-control device actuating the pilot-control circuit.

2.4.5.3 Manual/Automatic Selection

a. Where combination manual and automatic control is specified and the automatic-control device actuates the pilot control circuit of a magnetic starter, the magnetic starter shall be provided with a three-position selector switch marked MANUAL-OFF-AUTOMATIC.

b. Connections to the selector switch shall only allow the normal automatic regulatory control devices to be bypassed when the switch is in the Manual position; all safety control devices, such as low-or high-pressure cutouts, high-temperature cutouts, and motor-overload protective devices, shall be connected in the motor-control circuit in both the Manual and the Automatic positions of the selector switch. Control circuit connections to any MANUAL-OFF-AUTOMATIC switch or to more than one automatic regulatory control device shall be made in accordance with wiring diagram approved by the contracting Officer unless such diagram is included on the drawings. All controls shall be 120 volts or less unless otherwise indicated.

2.4.6 Motor Control Centers

Control centers shall be indoor type and shall contain combination starters and other equipment as indicated. Control centers shall be NEMA ICS 2, Class I, Type B. Each control center shall be mounted on floor sills or mounting channels. Each circuit shall have a suitable metal or laminated plastic nameplate with white cut letters and phenolic minic bus. Motor control centers shall be provided with a full-length ground bus bar. The first and last vertical sections shall have a removable end plate for future extension of the motor control center and motor control center horizontal bus.

2.5 LOW-VOLTAGE FUSES

2.5.1 General

Low-voltage fuses shall conform to NEMA FU 1. Time delay and nontime delay options shall be as shown. Equipment provided under this contract shall be provided with a complete set of properly rated fuses when the equipment manufacturer utilizes fuses in the manufacture of the equipment, or if current-limiting fuses are required to be installed to limit the ampere-interrupting capacity of circuit breakers or equipment to less than the maximum available fault current at the location of the equipment to be installed. Fuses shall have a voltage rating of not less than the phase-to-phase circuit voltage, and shall have the time-current characteristics requires for effective power system coordination.

2.5.2 Cartridge Fuses; Noncurrent-Limiting Type

Cartridge fuses of the noncurrent-limiting type shall be Class H, nonrenewable, dual element, time lag type and shall have interrupting capacity of 10,000 amperes. Class H Fuses shall conform to UL 198B. At 500 percent current, cartridge fuses shall not blow in less than 10 seconds. Cartridge fuses shall be used for circuits rated in excess of 30 amperes, 125 volts, except where current-limiting fuses are indicated.

2.6 MEDIUM-VOLTAGE AND HIGH-VOLTAGE FUSES

2.6.1 General

Medium-voltage and high-voltage fuses shall conform to NEMA SG 2 and shall be distribution fuse cutouts or power fuses, E-rated, C-rated, or R-rated current-limiting fuses as shown.

2.6.2 Construction

Units shall be suitable for indoor use. Fuses shall have integral blown-fuse indicators. All ratings shall be clearly visible.

2.6.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Continuous-current ratings shall be as shown.

2.6.3.1 Power Fuses

Expulsion power fuses shall have ratings in accordance with ANSI C37.46 and as follows:

a. Nominal voltage.........15 kV class, 12,470 volt, 3-phase
b. Rated maximum voltage..............................15,000
c. Maximum symmetrical interrupting capacity..........85,000
d. Rated continuous current...........................As indicated
e. BIL..95

2.6.3.2 E-Rated, Current-Limiting Power Fuses

E-rated, current-limiting, power fuses shall conform to ANSI C37.46.

2.6.3.3 C-Rated, Current-Limiting Fuses

C-rated, current-limiting, power fuses shall open in 1000 seconds at currents between 170 and 240 percent of the C rating.

2.6.3.4 R-Rated, Current-Limiting Fuses

R-rated, current-limiting, fuses shall be used with medium-voltage motor controllers only. R-rated fuses shall conform to ANSI C37.46.

2.7 MOTOR SHORT-CIRCUIT PROTECTOR (MSCP)

2.7.1 General

Motor short-circuit protectors shall conform to UL 508 and shall be provided as shown. Protectors shall be used only as part of a combination motor controller which provides coordinated motor branch-circuit overload and short-circuit protection, and shall be rated in accordance with the requirements of NFPA 70.

2.7.2 Construction

Motor short-circuit protector bodies shall be constructed of high temperature, dimensionally stable, long life, nonhygroscopic materials. Protectors shall fit special MSCP mounting clips and shall not be interchangeable with any commercially available fuses. Protectors shall have 100 percent one-way interchangeability within the A-Y letter designations. All ratings shall be clearly visible.

2.7.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Letter designations shall be A through Y for motor controller Sizes 0, 1, 2, 3, 4, and 5, with 100,000 amperes interrupting capacity rating. Letter designations shall correspond to controller sizes as follows:

CONTROLLER SIZE MSCP DESIGNATION

NEMA 0 A-N

NEMA 1 A-P

NEMA 2 A-S

NEMA 3 A-U

NEMA 4 A-W

NEMA 5 A-Y

2.8 MOLDED-CASE CIRCUIT BREAKERS

2.8.1 General

Molded-case circuit breakers shall conform to NEMA AB 1 and UL 489. Circuit breakers may be installed in panelboards, switchboards, enclosures, motor control centers, or combination motor controllers. Circuit breakers and circuit breaker enclosures located in hazardous (classified) areas shall conform to UL 877.

2.8.2 Construction

Molded-case circuit breakers shall be assembled as an integral unit in a supporting and enclosing housing of glass reinforced insulating material providing high dielectric strength. Circuit breakers shall be suitable for mounting and operating in any position. Lugs shall be listed for copper conductors only in accordance with UL 486E. Single-pole circuit breakers shall be full module size with not more than one pole per module. Multi-pole circuit breakers shall be of the common-trip type having a single operating handle such that an overload or short circuit on any one pole will result in all poles opening simultaneously. Sizes of 100 amperes or less may consist of single-pole breakers permanently factory assembled into a multi-pole unit having an internal, mechanical, nontamperable common-trip mechanism and external handle ties. All circuit breakers shall have a quick-make, quick-break overcenter toggle-type mechanism, and the handle mechanism shall be trip-free to prevent holding the contacts closed against a short-circuit or sustained overload. All circuit breaker handles shall assume a position between "ON" and "OFF" when tripped automatically. All ratings shall be clearly visible.

2.8.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. The interrupting rating of the circuit breakers shall be at least equal to the available short-circuit current at the line terminals of the circuit breaker and correspond to the UL listed integrated short-circuit current rating specified for the panelboards and switchboards. Molded-case circuit breakers shall have nominal voltage ratings, maximum continuous-current ratings, and maximum short-circuit interrupting ratings in accordance with NEMA AB 1. Ratings shall be coordinated with system X/R ratio.

2.8.4 Thermal-Magnetic Trip Elements

Thermal magnetic circuit breakers shall be provided as shown. Automatic operation shall be obtained by means of thermal-magnetic tripping devices located in each pole providing inverse time delay and instantaneous circuit protection. The instantaneous magnetic trip shall be adjustable and accessible from the front of all circuit breakers on frame sizes above 600 amperes.

2.8.5 Solid-State Trip Elements

Solid-state circuit breakers shall be provided as shown. All electronics shall be self-contained and require no external relaying, power supply, or accessories. Printed circuit cards shall be treated to resist moisture absorption, fungus growth, and signal leakage. All electronics shall be housed in an enclosure which provides protection against arcs, magnetic interference, dust, and other contaminants. Solid-state sensing shall measure true RMS current with error less than one percent on systems with distortions through the 13th harmonic. Peak or average actuating devices are not acceptable. Current sensors shall be toroidal construction, encased in a plastic housing filled with epoxy to protect against damage and moisture and shall be integrally mounted on the breaker. Where indicated on the drawings, circuit breaker frames shall be rated for 100 percent continuous duty. Circuit breakers shall have tripping features as shown on the drawings and as described below:

a. Long-time current pick-up, adjustable from 50 percent to 100 percent of continuous current rating.

b. Adjustable long-time delay.

c. Short-time current pick-up, adjustable from 1.5 to 9 times long-time current setting.

d. Adjustable short-time delay.

e. Short-time I square times t switch.

f. Instantaneous current pick-up, adjustable from 1.5 to 9 times long-time current setting.

g. Ground-fault pick-up, adjustable from 20 percent to 60 percent of sensor rating, but in no case greater than 1200 amperes. Sensing of ground-fault current at the main bonding jumper or ground strap shall not be permitted. Zone-selective interlocking shall be provided as shown.

h. Adjustable ground-fault delay.

i. Ground-fault I square times t switch.

j. Overload and Short-circuit and Ground-fault trip indicators shall be provided.

2.8.6 Current-Limiting Circuit Breakers

Current-limiting circuit breakers shall be provided as shown. Current-limiting circuit breakers shall limit the let-through I square times t to a value less than the I square times t of one-half cycle of the symmetrical short-circuit current waveform. On fault currents below the threshold of limitation, breakers shall provide conventional overload and short-circuit protection. Integrally-fused circuit breakers shall not be used.

2.8.7 SWD Circuit Breakers

Circuit breakers rated 15 amperes or 20 amperes and intended to switch 277 volts or less fluorescent lighting loads shall be marked "SWD."

2.8.8 HACR Circuit Breakers

Circuit breakers 60 amperes or below, 240 volts, 1-pole or 2-pole, intended to protect multi-motor and combination-load installations involved in heating, air conditioning, and refrigerating equipment shall be marked "Listed HACR Type."

2.8.9 Motor Circuit Protectors (MCP)

Motor circuit protectors shall conform to NEMA AB 1 and UL 489 and shall be provided as shown. MCPs shall consist of an adjustable instantaneous trip circuit breaker in conjunction with a combination motor controller which provides coordinated motor circuit overload and short-circuit protection. Motor Circuit Protectors shall be rated in accordance with NFPA 70.

2.9 LOW-VOLTAGE POWER CIRCUIT BREAKERS

2.9.1 Construction

Low-voltage power circuit breakers shall conform to IEEE C37.13, ANSI C37.16, and NEMA SG 6 and shall be three-pole, single-throw, stored energy, electrically operated, with drawout mounting. Solid-state trip elements which require no external power connections shall be provided. Circuit breakers shall have an open/close contact position indicator, charged/discharged stored energy indicator, primary disconnect devices, and a mechanical interlock to prevent making or breaking contact of the primary disconnects when the circuit breaker is closed. Control voltage shall be 120 V ac. The circuit breaker enclosure shall be suitable for its intended location.

2.9.2 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Circuit breakers shall be rated for 100 percent continuous duty and shall have trip current ratings and frame sizes as shown. Nominal voltage ratings, maximum continuous-current ratings, and maximum short-circuit interrupting ratings shall be in accordance with ANSI C37.16. Tripping features shall be as follows:

a. Long-time current pick-up, adjustable from 50 percent to 100 percent of sensor current rating.

b. Adjustable long-time delay.

c. Short-time current pick-up, adjustable from 1.5 to 9 times long-time current setting.

d. Adjustable short-time delay.

e. Short-time I square times t switch.

f. Instantaneous current pick-up, adjustable from 1.5 to 9 times long-time current setting.

g. Ground-fault pick-up, adjustable from 20 percent to 60 percent of sensor rating, but in no case greater than 1200 amperes. Sensing of ground-fault current at the main bonding jumper or ground strap shall not be permitted. Zone-selective interlocking shall be provided as shown.

h. Adjustable ground-fault delay.

i. Ground-fault I square times t switch.

j. Short-circuit and Ground-fault trip indicators shall be provided.

2.10 MEDIUM-VOLTAGE CIRCUIT BREAKERS/INTERRUPTERS

2.10.1 Metal-Enclosed Type

Circuit breakers shall be of the drawout type, in accordance with IEEE C37.20.1 and NEMA SG 6.

2.10.2 Metal-Clad Type

Circuit breakers shall comply with IEEE C37.04 and shall consist of items listed for such units in NEMA SG 6.

2.10.3 Vacuum Interrupters

Vacuum interrupters shall be hermetically-sealed in a high vacuum to protect contact from moisture and contamination. Circuit breakers shall have provisions for slow closing of contacts and have a readily contact wear indicator. Tripping time shall not exceed five cycles.

2.10.4 Ratings

Main buses shall be three-phase three-wire with a continuous current rating of 1200 amperes rms. Switchgear ratings at 60 Hz shall be in accordance with ANSI C37.06 and as follows:

Maximum voltage......................12,470, 3-phase

Nominal voltage class.............................15

BIL..95 kV

Maximum symmetrical interrupting capacity.........as indicated

3-second short-time-current carrying capacity.....as indicated
Rated continuous current...............as shown

2.11 OIL CIRCUIT BREAKERS FOR SUBSTATIONS

2.11.1 Incoming Line Circuit Breakers for Substations

Incoming line circuit breakers shall be coordinated with the requirements of the serving utility, and of the protected transformer, and shall include the following control and monitoring system items that shall be mounted in the instrument and relay cabinet.

a. An ammeter and an ammeter switch.

b. A circuit breaker control switch for local and remote control operation.

c. Three overcurrent relays or single 3-phase, devices 50/51.

d. One residually-connected ground-overcurrent relay or single 3-phase, device 50/51N.

e. Three directional overcurrent relays or single 3-phase, device 67.

f. One ground-directional-overcurrent relay, device 67N.

g. Three phase secondary potential test blocks with associated test plug, quantity as shown.

h. Three phase secondary current test blocks with associated test plug for each three-phase set of current transformers, as indicated.

2.11.2 Line Tie Circuit Breakers for Substations

The line tie circuit breaker shall be rated the same as the incoming line units, and shall be electrically and mechanically interlocked with other high-voltage items of equipment as shown. The line tie circuit breaker shall be equipped with control and monitoring system items the same as described for the incoming line circuit breaker. The instrument and relay cabinet shall house the same equipment listed for the incoming line circuit breaker cabinet. The cabinet shall also house three bus differential relays or single 3-phase, device 87B, and an auxiliary lockout relay, device 86B.

2.12 SUBSTATION AND SWITCHGEAR PROTECTIVE RELAYS

Solid-stateand Microprocessor-based protective relays shall be as shown and shall be of a type specifically designed for use on power switchgear or associated electric power apparatus. Protective relays shall conform to IEEE C37.90. Relays and auxiliaries shall suitable for operation with the instrument transformer ratios and connections provided.

2.12.1 Construction

Relays for installation in metal-clad switchgear shall be of the semi-flush, rectangular, back-connected, dustproof, switchboard type. Cases shall have a black finish and window-type removable covers capable of being sealed against tampering. Relays shall be of a type that can be withdrawn, through approved sliding contacts, from fronts of panels or doors without opening current transformer secondary circuits, disturbing external circuits, or requiring disconnection of any relay leads. Necessary test devices shall be incorporated within each relay and shall provide a means for testing either from an external source of electric power or from associated instrument transformers. Each relay shall be provided with an operation indicator and an external target reset device. Relays shall have necessary auxiliaries for proper operation. Relays and auxiliaries shall be suitable for operation with the instrument transformer ratios and connections provided.

2.12.2 Ratings

Relays shall be the manufacturer's standard items of equipments with appropriate ranges for time dial, tap, and other settings. Relay device numbers shall correspond to the function names and descriptions of IEEE C37.2.

2.12.3 Overcurrent Relays

Overcurrent relays shall be as follows:

a. Phase overcurrent relays for main and tie circuit breakers shall be 3-phase, nondirectional, solid-state or microprocessor-based type, time delay, device 51, current taps as indicated with characteristic curves that are very inverse as indicated.

b. Ground overcurrent relays for main circuit breakers shall be nondirectional, solid-state or microprocessor-based type, time delay, device 51G wired to a current transformer in the source transformer neutral-to-ground connection or 51N, residually connected as indicated and with characteristic curves that are inverse or extremely inverse as indicated.

c. Ground overcurrent relays for tie circuit breakers shall be nondirectional, solid-state or microprocessor-based type, time delay, device 51N, residually connected, with current taps as indicated and with characteristic curves that are definite time or very inverse or extremely inverse as indicated.

d. Phase overcurrent relays for feeder circuit breakers shall be single-phase, nondirectional, solid-state or microprocessor-based type, device 50/51, with instantaneous-current pick-up range with time-delay-current taps as indicated and with characteristic curves that are very inverse or extremely inverse as indicated.

e. Ground overcurrent relays for feeder circuit breakers shall be nondirectional, solid-state or microprocessor-based type instantaneous, device 50N, residually as indicated.

2.12.4 Bus Differential and Lockout Relays

Bus differential relay, device 87B, shall be of the three-phase or single-phase, high-speed impedance differential type suitable for protection of buses. Lockout relay, device 86B, shall be of a type which, when used in conjunction with the 87B relay, trips and locks out the indicated circuit breaker.

2.13 INSTRUMENT TRANSFORMERS

2.13.1 General

Instrument transformers shall comply with ANSI C12.11 and IEEE C57.13. Instrument transformers shall be configured for mounting in/on the device to which they are applied. Polarity marks on instrument transformers shall be visually evident and shown on the drawings.

2.13.2 Current Transformers

Unless otherwise indicated, bar, wound, or window-type transformers are acceptable; and except for window-type units installed over insulated buses, transformers shall have a BIL rating consistent with the rated BIL of the associated switchgear or electric power apparatus bushings, buses or conductors. Current transformers shall have the indicated ratios. The continuous thermal-current rating factor shall be not less than 1.5. Other thermal and mechanical ratings of current transformers and their primary leads shall be coordinated with the design of the circuit breaker and shall be not less than the momentary rating of the associated circuit breaker. Circuit protectors shall be provided across secondary leads of the current transformers to prevent the accidental open-circuiting of the transformers while energized. Each terminal of each current transformer shall be connected to a short-circuiting terminal block in the circuit interrupting mechanism cabinet, power transformer terminal cabinet, and in the associated instrument and relay cabinets.

2.13.2.1 Current Transformers for Metal-Clad Switchgear

Single-ratio units, used for metering and relaying, shall have a metering accuracy class rating of B.

2.13.2.2 Current Transformers for kW Hour and Demand Metering (Low Voltage)

Current transformers shall conform to IEEE C57.13. Current transformers with a metering accuracy Class of 0.3, with a minimum RF of 86 degrees F, with 600-volt insulation, and 10 kV BIL shall be provided.

2.13.2.3 Voltage Transformers

Voltage transformers shall have indicated ratios. Units shall have an accuracy rating of +/- 1 percent. Voltage transformers shall be of the drawout type having current-limiting fuses in both primary and secondary circuits. Mechanical interlocks shall prevent removal of fuses, unless the associated voltage transformer is in a drawout position. Voltage transformer compartments shall have hinged doors.

2.14 COORDINATED POWER SYSTEM PROTECTION

Analyses shall be prepared to demonstrate that the equipment selected and system constructed meet the contract requirements for ratings, coordination, and protection. They shall include a load flow analysis, a fault current analysis, and a protective device coordination study. The studies shall be performed by a registered professional engineer with demonstrated experience in power system coordination in the last 3 years.

The Contractor shall provide a list of references complete with points of contact, addresses and telephone numbers. The selection of the engineer is subject to the approval of the Contracting Officer.

2.14.1 Scope of Analyses

The fault current analysis, and protective device coordination study shall begin at: the source bus and extend down to system buses where fault availability is 10,000 amperes (symmetrical) for building/facility 600 volt level distribution buses.

2.14.2 Determination of Facts

The time-current characteristics, features, and nameplate data for each protective device shall be determined and documented. The Contractor shall coordinate with the commercial power company for fault current availability at the site.

2.14.3 Single Line Diagram

A single line diagram shall be prepared to show the electrical system buses, devices, transformation points, and all sources of fault current (including generator and motor contributions). A fault-impedance diagram or a computer analysis diagram may be provided. Each bus, device or transformation point shall have a unique identifier. If a fault-impedance diagram is provided, impedance data shall be shown. Location of switches, breakers, and circuit interrupting devices shall be shown on the diagram together with available fault data, and the device interrupting rating.

2.14.4 Fault Current Analysis

2.14.4.1 Method

The fault current analysis shall be performed in accordance with methods described in IEEE Std 242, and IEEE Std 399.

2.14.4.2 Data

Actual data shall be utilized in fault calculations. Bus characteristics and transformer impedance shall be those proposed. Data shall be documented in the report.

2.14.4.3 Fault Current Availability

Balanced three-phase fault, bolted line-to-line fault, and line-to-ground fault current values shall be provided at each voltage transformation point and at each power distribution bus. The maximum and minimum values of fault available at each location shall be shown in tabular form on the diagram or in the report.

2.14.5 Coordination Study

The study shall demonstrate that the maximum possible degree of selectivity has been obtained between devices specified, consistent with protection of equipment and conductors from damage from overloads and fault conditions. The study shall include a description of the coordination of the protective devices in this project. A written narrative shall be provided describing: which devices may operate in the event of a fault at each bus;

the logic used to arrive at device ratings and settings; situations where system coordination is not achievable due to device limitations (an analysis of any device curves which overlap); coordination between upstream and downstream devices; and relay settings. Recommendations to improve or enhance system reliability, and detail where such changes would involve additions or modifications to the contract and cost damages (addition or reduction) shall be provided. Composite coordination plots shall be provided on log-log graph paper.

2.14.6 Study report

a. The report shall include a narrative describing: the analyses performed; the bases and methods used; and the desired method of coordinated protection of the power system.

b. The study shall include descriptive and technical data for existing devices and new protective devices proposed. The data shall include manufacturers published data, nameplate data, and definition of the fixed or adjustable features of the existing or new protective devices.

c. The report shall document utility company data including system voltages, fault MVA, system X/R ratio, time-current characteristic curves, current transformer ratios, and relay device numbers and settings; and existing power system data including time-current characteristic curves and protective device ratings and settings.

d. The report shall contain fully coordinated composite time-current characteristics curves for each bus in the system, as required to ensure coordinated power system protection between protective devices or equipment. The report shall include recommended ratings and settings of all protective devices in tabulated form.

e. The report shall provide the calculation performed for the analyses, including computer analysis programs utilized. The name of the software package, developer, and version number shall be provided.

PART 3 EXECUTION

3.1 VERIFICATION OF DIMENSIONS

After becoming familiar with details of the work, the Contractor shall verify dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing any work.

3.2 INSTALLATION

Protective devices shall be installed in accordance with the manufacturer's published instructions and in accordance with the requirements of NFPA 70 and IEEE C2.

3.3 FIELD TESTING

3.3.1 General

Field testing shall be performed in the presence of the Contracting Officer. The Contractor shall notify the Contracting Officer 14 days prior to conducting tests. The Contractor shall furnish all materials, labor,

and equipment necessary to conduct field tests. The Contractor shall perform all tests and inspections recommended by the manufacturer unless specifically waived by the Contracting Officer. The Contractor shall maintain a written record of all tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results.

3.3.2 Safety

The Contractor shall provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. The Contractor shall replace any devices or equipment which are damaged due to improper test procedures or handling.

3.3.3 Molded-Case Circuit Breakers

Circuit breakers shall be visually inspected, operated manually, and connections checked for tightness. Current ratings shall be verified and adjustable settings incorporated in accordance with the coordination study.

3.3.4 Power Circuit Breakers

3.3.4.1 General

The Contractor shall visually inspect the circuit breaker and operate the circuit breaker manually; adjust and clean primary contacts in accordance with manufacturer's published instructions; check tolerances and clearances; check for proper lubrication; and ensure that all connections are tight. For electrically operated circuit breakers, the Contractor shall verify operating voltages on closing and tripping coils. The Contractor shall verify fuse ratings in control circuits; electrically operate the breaker, where applicable; and implement settings in accordance with the coordination study.

3.3.4.2 Power Circuit Breaker Tests

Power circuit breakers shall be tested in accordance with ANSI C37.50.

3.3.5 Protective Relays

Protective relays shall be visually and mechanically inspected, adjusted, tested, and calibrated in accordance with the manufacturer's published instructions. Tests shall include pick-up, timing, contact action, restraint, and other aspects necessary to ensure proper calibration and operation. Relay settings shall be implemented in accordance with the coordination study. Relay contacts shall be manually or electrically operated to verify that the proper breakers and alarms initiate. Relaying current transformers shall be field tested in accordance with IEEE C57.13.

-- End of Section --

SECTION 16510
INTERIOR LIGHTING
07/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A 580/A 580M (1998; R 2004) Stainless Steel Wire

ASTM A 641/A 641M (2003) Zinc-Coated (Galvanized) Carbon Steel Wire

CALIFORNIA ENERGY COMMISSION (CEC)

Title 24 (1978; R 2005) California's Energy Efficiency Standards for Residential and Nonresidential Buildings
GREEN SEAL (GS)

GC-12 (1997) Occupancy Sensors

ILLUMINATING ENGINEERING SOCIETY OF NORTH AMERICA (IESNA)

IESNA HB-9 (2000) Lighting Handbook

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2 (2002) National Electrical Safety Code

IEEE C62.41 (1991; R 1995) Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits

IEEE Std 100 (2000) The Authoritave Dictionary of IEEE Standards Terms

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250 (2003) Enclosures for Electrical Equipment (1000 Volts Maximum)

NEMA C78.81 (2003) Electric Lamps - Double-capped Fluorescent Lamps Dimensional and Electrical Characteristics

NEMA C78.901 (2001) Electric Lamps - Single Base Fluorescent Lamps Dimensional and Electrical Characteristics

NEMA C82.11	(2002) High-Frequency Fluorescent Lamp Ballasts
NEMA C82.4	(1992) Ballasts for High-Intensity-Discharge and Low-Pressure Sodium Lamps (Multiple-Supply Type)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 101	(2003) Life Safety Code
NFPA 70	(2005) National Electrical Code
NFPA 90A	(2002) Installation of Air Conditioning and Ventilating Systems

UNDERWRITERS LABORATORIES (UL)

UL 1029	(1994; Rev thru Feb 2001) High-Intensity-Discharge Lamp Ballasts
UL 1598	(2004) Luminaires
UL 844	(1995; Rev thru Mar 1999) Electric Lighting Fixtures for Use in Hazardous (Classified) Locations
UL 924	(1995; Rev thru Jul 2001) Emergency Lighting and Power Equipment
UL 935	(2001) Fluorescent-Lamp Ballasts

1.2 RELATED REQUIREMENTS

Materials not considered to be lighting equipment or lighting fixture accessories are specified in Section 16402 INTERIOR DISTRIBUTION SYSTEM. Lighting fixtures and accessories mounted on exterior surfaces of buildings are specified in this section.

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE Std 100.

b. Average life is the time after which 50 percent will have failed and 50 percent will have survived under normal conditions.

c. Total harmonic distortion (THD) is the root mean square (RMS) of all the harmonic components divided by the total fundamental current.

1.4 SYSTEM DESCRIPTION

1.4.1 Lighting Control System

Provide lighting control system as indicated. Lighting control equipment shall include, if indicated: contactors, dimming systems, control modules power packs, dimming ballasts, occupancy sensors, and light level sensors.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

Data, drawings, and reports shall employ the terminology, classifications, and methods prescribed by the IESNA HB-9, as applicable, for the lighting system specified.

SD-03 Product Data

Fluorescent lighting fixtures; G

Fluorescent electronic ballasts; G

Fluorescent lamps; G

High-intensity-discharge (HID) lighting fixtures; G

HID ballasts; G

Exit signs; G

Emergency lighting equipment; G

Central emergency system; G

Occupancy sensors; G

Electronic dimming ballast; G

Dimming ballast controls; G

Light Level Sensor; G

SD-04 Samples

ting fixtures, complete with lamps and ballasts; G

SD-06 Test Reports

Operating test

Submit test results as stated in paragraph entitled "Field Quality Control."

SD-10 Operation and Maintenance Data

Lighting Control System, Data Package 5; G

Submit operation and maintenance data in accordance with Section 01781 OPERATION AND MAINTENANCE DATA and as specified herein, showing all light fixtures, control modules, control zones, occupancy sensors, light level sensors, power packs, dimming ballasts, schematic diagrams and all interconnecting control wire, conduit, and associated hardware.

1.6 QUALITY ASSURANCE

1.6.1 Fluorescent Electronic Ballasts

Submit ballast catalog data as required in the paragraph entitled "Fluorescent Lamp Electronic Ballasts" contained herein. As an option, submit the fluorescent fixture manufacturer's electronic ballast specification information in lieu of the actual ballast manufacturer's catalog data. This information shall include published specifications and sketches, which covers the information required by the paragraph entitled "Fluorescent Lamp Electronic Ballasts" herein. This information may be supplemented by catalog data if required, and shall contain a list of vendors with vendor part numbers.

1.6.2 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.6.3 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section. All electrical products shall be installed according to the manufactures instructions.

1.6.3.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.6.3.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.7 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.7.1 Electronic Ballast Warranty

Furnish the electronic ballast manufacturer's warranty. The warranty period shall not be less than 5 years from the date of manufacture of the electronic ballast. Ballast assembly in the lighting fixture, transportation, and on-site storage shall not exceed 12 months, thereby permitting 4 years of the ballast 5 year warranty to be in service and energized. The warranty shall state that the malfunctioning ballast shall be exchanged by the manufacturer and promptly shipped to the using Government facility. The replacement ballast shall be identical to, or an improvement upon, the original design of the malfunctioning ballast.

PART 2 PRODUCTS

2.1 FLUORESCENT LIGHTING FIXTURES

UL 1598. Fluorescent fixtures shall have electronic ballasts unless specifically indicated otherwise.

2.1.1 Fluorescent Lamp Electronic Ballasts

The electronic ballast shall as a minimum meet the following characteristics:

a. Ballast shall comply with UL 935, NEMA C82.11, NFPA 70, and Title 24 unless specified otherwise. Ballast shall be 100% electronic high frequency type with no magnetic core and coil components. Ballast shall provide transient immunity as recommended by IEEE C62.41. Ballast shall be designed for the wattage of the lamps used in the indicated application. Ballasts shall be designed to operate on the voltage system to which they are connected.

b. Power factor shall be 0.95 (minimum).

c. Ballast shall operate at a frequency of 20,000 Hertz (minimum). Ballast shall be compatible with and not cause interference with the operation of occupancy sensors or other infrared control systems. Provide ballasts operating at or above 40,000 Hertz where available.

d. Ballast shall have light regulation of plus or minus 10 percent lumen output with a plus or minus 10 percent input voltage regulation. Ballast shall have 10 percent flicker (maximum) using any compatible lamp.

e. Ballast factor shall be between 0.95 (minimum) and 1.00 (maximum). Current crest factor shall be 1.7 (maximum).

f. Ballast shall be UL listed Class P with a sound rating of "A."

g. Ballast shall have circuit diagrams and lamp connections displayed on the ballast.

h. Ballasts for compact fluorescent fixtures shall be multi-voltagee type with programmed start where available.

i. Ballasts for T-5 and smaller lamps shall have end-of-life protection circuits as required by NEMA C78.81 and NEMA C78.901 as applicable.

j. Ballast shall be capable of starting and maintaining operation at a minimum of 0 degrees F unless otherwise indicated.

k. Electronic ballast shall have a full replacement warranty of 5 years from date of manufacture as specified in paragraph entitled "Electronic Ballast Warranty" herein.

2.1.1.1 T-8 Lamp Ballast

a. Total harmonic distortion (THD): Shall be 10 percent (maximum).

b. Input wattage.

1. 32 watts (maximum) when operating one F32T8 lamp

2. 62 watts (maximum) when operating two F32T8 lamps

3. 92 watts (maximum) when operating three F32T8 lamps

4. 114 watts (maximum) when operating four F32T8 lamps

2.1.1.2 F17T8 Lamp Ballast

a. Total harmonic distortion (THD): Shall be 10 percent (maximum).

b. Input wattage:

1. 34 watts (maximum) when operating two F17T8 lamps.

2.1.2 Fluorescent Lamp Electronic Dimming Ballast

The electronic ballast shall as a minimum meet the following characteristics:

a. Ballast shall comply with NEMA C82.11, UL 935, and NFPA 70, unless specified otherwise. Ballast shall provide transient immunity as recommended by IEEE C62.41. Ballast dimming capability range shall be from 100 to 10 percent (minimum range) of light output, flicker free. Ballast shall start lamp at any preset light output setting without first having to go to full light output. Ballast shall be designed for the wattage of the lamps used in the indicated application. Ballasts shall be designed to operate on the voltage system to which they are connected.

b. Power factor shall be 0.95 (minimum) at full light output, and 0.90 (minimum) over the entire dimming range.

c. Ballast shall operate at a frequency of 20,000 Hertz (minimum). Ballast shall be compatible with and not cause interference with the operation of occupancy sensors or other infrared control systems. Provide ballasts operating at or above 40,000 Hertz where available.

d. Ballast factor at full light output shall be between 0.95 (minimum) and 1.00 (maximum). Current crest factor shall be 1.7 (maximum).

e. Ballast shall be UL listed Class P with a sound rating of "A".

f. Ballast shall have circuit diagrams and lamp connections displayed on the ballast.

g. Ballast shall be programmed start. Ballast may operate lamps in a series circuit configuration. Provide series/parallel wiring for programmed start ballasts where available.

h. Ballasts for compact fluorescent fixtures shall be multi-Voltage type with programmed start where available.

i. Total harmonic distortion (THD): Shall be 10 percent (maximum) over the entire dimming range.

j. Ballasts for T-5 and smaller lamps shall have end-of-life protection circuits as required by NEMA C78.81 and NEMA C78.901 as applicable.

2.1.2.1 T-8 Lamp Ballast

Input wattage, for indicated lamp quantity shall be:

a. 35 watts (maximum) when operating one F32T8 lamp.

b. 70 watts (maximum) when operating two F32T8 lamps.

2.1.3 Dimming Ballast Controls

The dimming ballast controls shall be a slide dimmer with on/off control. The slide dimmer shall be compatible with the ballast and control the ballast light output over the full dimming range. Electronic Low-voltage, 3-wire and 4-wire Fluorescent ballast control modules programable pre-set or scene control shall be used for Architectural dimming systems in the auditorium, conferance rooms Dimming ballast controls shall be approved by the ballast manufacturer.

2.1.4 Light Level Sensor

UL listed. Light level sensor shall be capable of detecting changes in ambient lighting levels, shall provide a dimming range of 20 percent to 100 percent, minimum, and shall be designed for use with dimming ballast and voltage system to which they are connected. Sensor shall be capable of controlling 40 electronic dimming ballast, minimum. Sensor light level shall be adjustable and have a set level range from 10 to 100 footcandles, minimum. Sensor shall have a bypass function to electrically override sensor control.

2.1.5 Fluorescent Lamps

a. T-8 rapid start low mercury lamps shall be rated 32 watts (maximum), 2800 initial lumens (minimum), CRI of 80 (minimum), color temperature of 4100 K, and an average rated life of 20,000 hours. All lamps shall be low mercury lamps and shall have passed the EPA Toxicity Characteristic Leachate Procedure (TCLP) for mercury by using the lamp sample preparation procedure described in NEMA LL 1.

b. T-8 rapid start lamp, 17 watt (maximum), nominal length of 24 inches, 1300 initial lumens, CRI of 80 (minimum), color temperature of 4100 K, and an average rated life of 20,000 hours.

c. T-8 instant start lamp, 59 watts (maximum), nominal length of 96 inches, minimum CRI of 80, 5700 initial lumens, color temperature of 4100 K, and average rated life of 15,000 hours.

d. T-12 slim line lamps shall be rated 60 watts (maximum), 5750 initial lumens (minimum), 12,000 hours average rated life.

e. T-5, long twin tube fluorescent lamp, 40 watts (maximum), 4100 K, 22.6 inches maximum length, 20,000 hours average rated life, 3150 initial lumens, CRI of 80 (minimum), 2G11 Type base, 90 to 100 lumens/watt depending on wattage.

Average rated life is based on 3 hours operating per start.

2.1.6 Compact Fluorescent Fixtures

Compact fluorescent fixtures shall be manufactured specifically for compact fluorescent lamps with ballasts integral to the fixture. Providing assemblies designed to retrofit incandescent fixtures is prohibited except when specifically indicated for renovation of existing fixtures. Fixtures shall use lamps as indicated, with a minimum CRI of 80.

2.1.7 Open-Tube Fluorescent Fixtures

Provide with self-locking sockets, or lamp retainers (two per lamp). Provide lamps with shatter resistant coating, non-yellowing, nominal thickness of 15 mils, and with 97 percent (minimum) light.

2.1.8 Air Handling Fixtures

Fixtures used as air handling registers shall meet requirements of NFPA 90A.

2.1.9 Electromagnetic Interference Filters

Provide in each fluorescent fixture mounted in shielded enclosures to suppress electromagnetic interference in the AM radio band form 500 to 1700 k HZ...

2.2 HIGH-INTENSITY-DISCHARGE (HID) LIGHTING FIXTURES

UL 1598. Provide HID fixtures with tempered glass lenses when using metal-halide lamps.

2.2.1 HID Ballasts

UL 1029 and NEMA C82.4 and shall be constant wattage autotransformer (CWA) or regulator, high power factor type (minimum 90%). Provide single-lamp ballasts which shall have a minimum starting temperature of minus 30 degrees C. Ballasts shall be:

a. Designed to operate on the voltage system to which they are connected.
b. Designed for installation in a normal ambient temperature of 40 degrees C.
c. Constructed so that open circuit operation will not reduce the average life.

2.3 RECESS- AND FLUSH-MOUNTED FIXTURES

Provide type that can be relamped from the bottom. Access to ballast shall be from the bottom. Trim for the exposed surface of flush-mounted fixtures

shall be as indicated.
2.4 SUSPENDED FIXTURES

Provide hangers capable of supporting twice the combined weight of fixtures supported by hangers. Provide with swivel hangers to ensure a plumb installation. Hangers shall be cadmium-plated steel with a swivel-ball tapped for the conduit size. Hangers shall allow fixtures to swing within an angle of 45 degrees. Brace pendants 4 feet or longer to limit swinging. Single-unit suspended fluorescent fixtures shall have twin-stem hangers. Multiple-unit or continuous row fluorescent fixtures shall have a tubing or stem for wiring at one point and a tubing or rod suspension provided for each unit length of chassis, including one at each end of continuous chanel mounted. Rods shall be a minimum 0.18 inch diameter.

2.5 FIXTURES FOR HAZARDOUS LOCATIONS

In addition to requirements stated herein, provide fluorescent HID and incandescent fixtures for hazardous locations which conform to UL 844 or which have Factory Mutual certification for the class and division indicated.

2.6 SWITCHES

2.6.1 Toggle Switches

Provide toggle switches as specified in Section 16402 INTERIOR DISTRIBUTION SYSTEM.

2.7 EXIT SIGNS

UL 924, NFPA 70, and NFPA 101. Exit signs shall be remote-powered type. Exit signs shall utilize light emitting diode (LED) sources for long light source life and low energy use. Exit signs shall use no more than 5 watts.

2.7.1 Remote-Powered Exit Signs

Provide remote ac exit signs with provisions for wiring to external ac power sources. Provide signs with a minimum of two ac lamps.

2.8 EMERGENCY LIGHTING EQUIPMENT

UL 924, NFPA 70, and NFPA 101. Provide lamps in wattage indicated. Provide accessories required for remote-mounted lamps where indicated. Remote-mounted lamps shall be as indicated.

2.8.1 Emergency Lighting Unit

Provide as indicated. Emergency lighting units shall be rated for 12 volts, except units having no remote-mounted lamps and having no more than two unit-mounted lamps may be rated 6 volts. Equip units with brown-out sensitive circuit to activate battery when ac input falls to 75 percent of normal voltage and 15 minute time delay feature for areas with HID lighting. Provide integral self-testing module.

2.8.2 Fluorescent Battery Packs

Provide flourescent battery pack where indicated on the drawings or in the fixture schedule. The battery pack shall be factory or field installed within the fixture ballast channel. Upon interruption of normal power the battery pack automatically strikes and operates at reduced light output, poroviding optimum flare free illumination of a period of 90 minutes. The battery pack shall be compatible with T8 and T5 electronic, T12 magnetic, instant start, rapid start, and slimline ballasts. The battery pack shall operate any of the following:

a. one or two 2'- 4' fluorescent T8 or T-12
b. one 2'-4' T5,T8,T12 HO, long compact (biax) lamp
c. one 6'-8' fluorescent T8-T12 lamp

The battery shall be sealed, maintenance free, high temperature nickel-cadmium. The assembly shall be dual voltage rated at 120 and 277 volts, have a constant current type charger that will completely recharge a fully depleted battery to rated capacity within 72 hours. The inverter portion of the battery pack shall be a high effeiciency push-pull type

2.8.3 Switched Emergency Lighting

Provide a normally closed electrically held relay wired in parallel with wall switch to turn on all emergency lighting fixtures within the room upon a loss of normal power independent of the wall switch position. The relay shall have an coil rated for both 120 volt of 277 volt circuit, contact ratings of 20 Amperes at the circuit voltage, rated for 40,000 operations and ETL listed for emergency systems per UL 924.

2.9 CENTRAL EMERGENCY SYSTEM

Provide a in-line lighting inverter based emergency lighting UL 924 listed lighting inverter. Each system shall be rated to provide the indicated quanity of power to a 480/277 volt; 3 phase, 4 wire, 60 hz, sine wave AC emergency and life safety lighting system. for a minimum period of 90 minutes. AC system shall have an inverter output distortion of not more than 10 percent at unity power factor. The system shall be designed to handle surges during loss and recovery of power. The central emergency system lighting inverter shall be equiped with a fully rated manually operated bypass switch that will allow maintenance as well as removal of the rectifier/charger and/or inverter sections.

2.9.1 Operation

With normal power applied, batteries shall be automatically charged. Upon loss of normal power, system shall maintain rated output for a period of 90 minutes without interruption. . Inverter shall have built-in protection when output is shorted or overloaded. When normal power resumes, the emergency system shall automatically return to normal operation and initiate recharging of the battery.

2.9.2 Battery Charginger

Provide two-rate charging for lead-calcium batteries. The charger shall be solid-state, completely automatic, maintaining the batteries in a fully charged condition, and recharging the batteries to full capacity as specified in UL 924.

2.9.3 Batteries

Batteries shall be sealed lead-calcium type, shall operate unattended, and shall require no maintenance, including no additional water, for a period of not less than 5 years.

2.9.4 Accessories

Provide visual indicators to indicate normal power, inverter power, and battery charger operation. Provide test switch to simulate power failure by interrupting the input line, load ammeter, automatic brown-out circuitry to switch to emergency power when input line voltage drops below 75 percent of normal value, and low voltage cutoff (LVD) to disconnect inverter when battery voltage drops to approximately 80 percent of nominal voltage. The lighting inverter Shall be fully capable of transmitting analog and digital parameters to the SCADA system using MODBUS protocall.

2.9.5 Enclosure

Provide a free-standing cabinet with floor stand. Cabinet construction shall be of 14 gage sheet steel with baked-on enamel finish and locking type latch.

2.10 OCCUPANCY SENSORS

UL listed. Comply with GC-12. Occupancy sensors and power packs shall be designed to operate on the voltage indicated. Sensors and power packs shall have circuitry that only allows load switching at or near zero current crossing of supply voltage. Occupancy sensor mounting as indicated. Sensor shall have an LED occupant detection indicator. Sensor shall have adjustable sensitivity and adjustable delayed-off time range of 5 minutes to 15 minutes. Wall mounted sensors match the color of adjacent wall plates as specified in Section 16402 INTERIOR DISTRIBUTION SYSTEM, ceiling mounted sensors shall be white. Ceiling mounted sensors shall have 360 degree coverage unless otherwise indicated.

a. Ultrasonic/Infrared Combination Sensor

Occupancy detection to turn lights on requires both ultrasonic and infrared sensor detection. Lights shall remain on if either the ultrasonic or infrared sensor detects movement. Infrared sensor shall have lens selected for indicated usage and daylight filter to prevent short wavelength infrared interference. Ultrasonic sensor frequency shall be crystal controlled.

2.11 SUPPORT HANGERS FOR LIGHTING FIXTURES IN SUSPENDED CEILINGS

2.11.1 Wires

ASTM A 641/A 641M, galvanized regular coating, soft temper, 0.1055 inches in diameter (12 gage).

2.11.2 Wires, for Humid Spaces

ASTM A 580/A 580M, composition 302 or 304, annealed stainless steel 0.1055 inches in diameter (12 gage).

2.11.3 Rods

Threaded steel rods, 3/16 inch diameter, zinc or cadmium coated.

2.12 EQUIPMENT IDENTIFICATION

2.12.1 Manufacturer's Nameplate

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.13 FACTORY APPLIED FINISH

Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations shall conform to IEEE C2, NFPA 70, and to the requirements specified herein.

3.1.1 Lamps

Lamps of the type, wattage, and voltage rating indicated shall be delivered to the project in the original cartons and installed just prior to project completion. Lamps installed and used for working light during construction shall be replaced prior to turnover to the Government if more than 15 percent of their rated life has been used. Lamps shall be tested for proper operation prior to turn-over and shall be replaced if necessary with new lamps from the original manufacturer.

3.1.2 Lighting Fixtures

Set lighting fixtures plumb, square, and level with ceiling and walls, in alignment with adjacent lighting fixtures, and secure in accordance with manufacturers' directions and approved drawings. Installation shall meet requirements of NFPA 70. Mounting heights specified or indicated shall be to the bottom of fixture for ceiling-mounted fixtures and to center of fixture for wall-mounted fixtures. Obtain approval of the exact mounting for lighting fixtures on the job before commencing installation and, where applicable, after coordinating with the type, style, and pattern of the ceiling being installed. Recessed and semi-recessed fixtures shall be independently supported from the building structure by a minimum of two wires or rods per fixture and located near each corner of each fixture. Ceiling grid clips are not allowed as an alternative to independently supported light fixtures. Round fixtures or fixtures smaller in size than the ceiling grid shall be independently supported from the building structure by a minimum of two wires or rods per fixture spaced approximately equidistant around the fixture. Do not support fixtures by ceiling acoustical panels. Where fixtures of sizes less than the ceiling grid are indicated to be centered in the acoustical panel, support such fixtures independently and provide at least two 3/4 inch metal channels spanning, and secured to, the ceiling tees for centering and aligning the fixture. Provide wires or rods for lighting fixture support in this section. Lighting fixtures installed in suspended ceilings shall also comply with the requirements of Section 09510 ACOUSTICAL CEILINGS.

3.1.3 Suspended Fixtures

Suspended fixtures shall be provided with 45 degree swivel hangers so that they hang plumb and shall be located with no obstructions within the 45 degree range in all directions. The stem, canopy and fixture shall be capable of 45 degree swing. Pendants, rods, or chains 4 feet or longer excluding fixture shall be braced to prevent swaying using three cables at 120 degree separation. Suspended fixtures in continuous rows shall have internal wireway systems for end to end wiring and shall be properly aligned to provide a straight and continuous row without bends, gaps, light leaks or filler pieces. Aligning splines shall be used on extruded aluminum fixtures to assure hairline joints. Steel fixtures shall be supported to prevent "oil-canning" effects. Fixture finishes shall be free of scratches, nicks, dents, and warps, and shall match the color and gloss specified. Pendants shall be finished to match fixtures. Canopies shall be finished to match the ceiling and shall be low profile unless otherwise shown. Maximum distance between suspension points shall be 10 feet or as recommended by the manufacturer, whichever is less.

3.1.4 Ballasts

3.1.4.1 Remote Ballasts

Remote type ballasts or transformers, where indicated, shall be mounted in a well ventilated, easily accessible location, within the maximum operating distance from the lamp, as designated by the manufacturer.

3.1.4.2 Electronic Dimming Ballasts

All electronic dimming ballasts controlled by the same controller shall be of the same manufacturer. All fluorescent lamps on electronic dimming ballast control shall be seasoned or burned in at full light output for 100 hours before dimming.

3.1.5 Exit Signs and Emergency Lighting Units

Wire exit signs and emergency lighting units ahead of the switch to the normal lighting circuit located in the same room or area.

3.1.5.1 Exit Signs

Wire exit signs shall be serve from the life safety inverter.. Signs shall have only one control, which shall be the circuit breaker in the emergency panel. Paint control device red and provide lockout.

3.1.5.2 Emergency Lighting from Central Emergency System

Wire emergency lighting powered from a central emergency system as indicated on the drawings.

3.1.6 Photocell Switch Aiming

Aim switch according to manufacturer's recommendations.

3.1.7 Occupancy Sensor

Provide quantity of sensor units indicated as a minimum. Provide additional units to give full coverage over controlled area. Full coverage shall provide hand and arm motion detection for office and administration

type areas and walking motion for industrial areas, warehouses, storage rooms and hallways. Locate the sensor(s) as indicated and in accordance with the manufacturer's recommendations to maximize energy savings and to avoid nuisance activation and deactivation due to sudden temperature or airflow changes and usage. Set sensor "on" duration to 10 minutes.

3.1.8 Light Level Sensor

Locate light level sensor as indicated and in accordance with the manufacturer's recommendations. Adjust sensor for 50 footcandles or for the indicated light level at the typical work plane for that area.

3.2 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting shall be as specified in Section 09900 PAINTS AND COATINGS.

3.3 FIELD QUALITY CONTROL

Upon completion of installation, verify that equipment is properly installed, connected, and adjusted. Conduct an operating test to show that equipment operates in accordance with requirements of this section.

3.3.1 Electronic Dimming Ballast

Test for full range of dimming capability. Observe for visually detectable flicker over full dimming range.

3.3.2 Occupancy Sensor

Test sensors for proper operation. Observe for light control over entire area being covered.

-- End of Section --

SECTION 16520
EXTERIOR LIGHTING
07/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO LTS-4	(2006) Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C136.21	(1987) Roadway Lighting Equipment - Vertical Tenons Used with Post-Top-Mounted Luminaires

ASTM INTERNATIONAL (ASTM)

ASTM A 123/A 123M	(2002) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 153/A 153M	(2005) Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM B 108	(2006) Aluminum-Alloy Permanent Mold Castings

ILLUMINATING ENGINEERING SOCIETY OF NORTH AMERICA (IESNA)

IESNA HB-9	(2000; Errata 2004; Errata 2005) Lighting Handbook

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2005) National Electrical Safety Code
IEEE Std 100	(2000) The Authoritave Dictionary of IEEE Standards Terms

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2003) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA C136.13	(1992) Roadway Lighting Equipment, Metal Brackets for Wood Poles
NEMA C136.3	(2005) Roadway and Area Lighting

Equipment Luminaire Attachments

NEMA C78.43 (2005) Electric Lamps - Single-Ended Metal-Halide Lamps

NEMA C82.4 (2002) Ballasts for High-Intensity-Discharge and Low-Pressure Sodium Lamps (Multiple-Supply Type)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2005; TIA 2005) National Electrical Code

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

Energy Star (1992; R 2006) Energy Star Energy Efficiency Labeling System

UNDERWRITERS LABORATORIES (UL)

UL 1029 (1994; Rev thru Feb 2006) Standard for Safety High-Intensity-Discharge Lamp Ballasts

UL 1598 (2004; Rev thru May 2006) Luminaires

1.2 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE Std 100.

b. Average life is the time after which 50 percent will have failed and 50 percent will have survived under normal conditions.

c. Groundline section is that portion between one foot above and 2 feet below the groundline.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Luminaire drawings; G

Poles; G

SD-03 Product Data

Energy Efficiency

Luminaires; G

Lamps; G

Ballasts; G

Aluminum poles; G

Brackets

SD-05 Design Data

Design Data for luminaires; G

SD-06 Test Reports

Operating test

Submit operating test results as stated in paragraph entitled "Field Quality Control."

1.4 QUALITY ASSURANCE

1.4.1 Drawing Requirements

1.4.1.1 Luminaire Drawings

Include dimensions, effective projected area (EPA), accessories, and installation and construction details. Photometric data, including zonal lumen data, average and minimum ratio, aiming diagram, and computerized candlepower distribution data shall accompany shop drawings.

1.4.1.2 Poles

Include dimensions, wind load determined in accordance with AASHTO LTS-4, pole deflection, pole class, and other applicable information.

1.4.2 Design Data for Luminaires

a. Distribution data according to IESNA classification type as defined in IESNA HB-9.

b. Computerized horizontal illumination levels in footcandles at ground level, taken every 10 feet. Include average maintained footcandle level and maximum and minimum ratio.

c. Amount of shielding on luminaires.

1.4.3 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.4.4 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.4.4.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.4.4.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Aluminum and Steel Poles

Do not store poles on ground. Support poles so they are at least one foot above ground level and growing vegetation. Do not remove factory-applied pole wrappings until just before installing pole.

1.6 SUSTAINABLE DESIGN REQUIREMENTS

1.6.1 Energy Efficiency

Comply with National Energy Policy Act and Energy Star requirements for lighting products. Submit documentation for Energy Star qualifications for equipment provided under this section. Submit data indicating lumens per watt efficiency and color rendition index of light source.

1.7 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 LUMINAIRES

UL 1598. Provide luminaires as indicated. Provide luminaires complete with lamps of number, type, and wattage indicated. Details, shapes, and dimensions are indicative of the general type desired, but are not intended to restrict selection to luminaires of a particular manufacturer. Luminaires of similar designs, light distribution and brightness characteristics, and of equal finish and quality will be acceptable as approved.

2.1.1 Lamps

2.1.1.1 Metal-Halide Lamps

Provide luminaires with tempered glass lens.

a. Single-ended, wattage as indicated, conforming to NEMA C78.43

Lamps shall have Luminaire Efficiency Ratings (LER) as follows:

a. Upward efficiency of 0%

   1. 150-399 watts: minimum 41 LER for closed fixture

b. Upward efficiency of 1%-10%

   1. 150-399 watts: minimum 56 LER for closed fixture

c. Upward efficiency greater than 20%

   1. 150-399 watts: minimum 62 LER for closed fixture; minimum 77 for open fixture

2.1.2 Ballasts for High-Intensity-Discharge (HID) Luminaires
UL 1029 and NEMA C82.4, and shall be constant wattage autotransformer (CWA) or regulator, high power-factor type (minimum 90%). Provide single-lamp ballasts which shall have a minimum starting temperature of minus 30 degrees C. Ballasts shall be:

a. Designed to operate on voltage system to which they are connected.

b. Constructed so that open circuit operation will not reduce the average life.

HID ballasts shall have a solid-state igniter/starter with an average life in the pulsing mode of 10,000 hours at the intended ambient temperature. Igniter case temperature shall not exceed 90 degrees C.

2.2 POLES

Provide poles designed for wind loading of 110 miles per hour at the base of the pole with a 1.3 wind gust factor and as determined in accordance with AASHTO LTS-4 while supporting luminaires and all other appurtenances indicated. The effective projected areas of luminaires and appurtenances used in calculations shall be specific for the actual products provided on each pole. Poles shall be anchor-base type designed for use with underground supply conductors. Poles shall have oval-shaped handhole having a minimum clear opening of 2.5 by 5 inches. Handhole cover shall be secured by stainless steel captive screws. Metal poles shall have an internal grounding connection accessible from the handhole near the bottom of each pole. Scratched, stained, chipped, or dented poles shall not be installed.

2.2.1 Aluminum Poles

Provide aluminum poles manufactured of corrosion resistant aluminum alloys conforming to AASHTO LTS-4 for Alloy 6063-T6 or Alloy 6005-T5 for wrought alloys and Alloy 356-T4 (3,5) for cast alloys. Poles shall be seamless extruded or spun seamless type with minimum 0.188 inch wall thickness. Provide a pole grounding connection designed to prevent electrolysis when used with copper ground wire. Tops of shafts shall be fitted with a round or tapered cover. Base shall be anchor bolt mounted, made of cast 356-T6 aluminum alloy in accordance with ASTM B 108 and shall be machined to receive the lower end of shaft. Joint between shaft and base shall be welded. Base cover shall be cast 356-T6 aluminum alloy in accordance with ASTM B 108. Hardware, except anchor bolts, shall be either 2024-T4 anodized aluminum alloy or stainless steel. Aluminum poles and brackets for site lighting shall have a dark anodic (anodized)bronze finish to match fixtures and shall not be painted. Manufacturer's standard provision shall be made for protecting the finish during shipment and installation. Minimum protection shall consist of spirally wrapping each pole shaft with protective paper secured with tape, and shipping small parts in boxes.

2.A2A.S2H T O SLtTeSe-l4 .P o lPersovide steel poles having minimum 11-gage steel with minimum yield/strength of 48,000 psi and hot-dipped galvanized in accordance with ASTM A 123/A 123M Blackfactory finish. Provide a pole grounding connection designed to prevent electrolysis when used with copper ground wire. Pole shall be direct set or anchor bolt mounted type. Poles shall have tapered tubular members, either round in cross section or polygonal.[Pole shafts shall be one piece. Poles shall be welded construction with no bolts, rivets, or other means of fastening except as specifically approved.] Pole markings shall be approximately 3 to 4 feet above grade and shall include manufacturer, year of manufacture, top and bottom diameters, and length.[Base covers for steel poles shall be structural quality hot-rolled carbon steel plate having a minimum yield of 36,000 psi.]

2.3 BRACKETS AND SUPPORTS

NEMA C136.3, NEMA C136.13, and ANSI C136.21, as applicable. Pole brackets shall be not less than 1 1/4 inch aluminum secured to pole. Slip-fitter or pipe-threaded brackets may be used, but brackets shall be coordinated to luminaires provided, and brackets for use with one type of luminaire shall be identical. Brackets for pole-mounted street lights shall correctly position luminaire no lower than mounting height indicated. Mount brackets not less than 24 feet above street. Special mountings or brackets shall be as indicated and shall be of metal which will not promote galvanic reaction with luminaire head.

2.4 POLE FOUNDATIONS

Poles shall be installed on a 3'-0" above finish grade concrete foundation ith embedded anchor bolts. Anchor bolts shall be steel rod having a minimum yield strength of 50,000 psi; the top 12 inches of the rod shall be galvanized in accordance with ASTM A 153/A 153M. Concrete shall be 3,000 psi.

2.5 EQUIPMENT IDENTIFICATION

2.5.1 Manufacturer's Nameplate

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.5.2 Pole Labels
Each pole shall be provided with a screw or rivet mounted stainless steel

tag indicating a unique pole number, circuit number, circuit voltage,lamp type and wattage.

2.6 FACTORY APPLIED FINISH

Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations shall conform to IEEE C2, NFPA 70, and to the requirements specified herein.

3.1.1 Aluminum and Steel Poles

Provide pole foundations with galvanized steel anchor bolts, threaded at the top end and bent 90 degrees at the bottom end. Provide ornamental covers to match pole and galvanized nuts and washers for anchor bolts. Concrete for anchor bases, polyvinyl chloride (PVC) conduit ells, and ground rods shall be as specified in Section 16302 UNDERGROUND ELECTRICAL AND DISTRIBUTION. Thoroughly compact backfill with compacting arranged to prevent pressure between conductor, jacket, or sheath and the end of conduit ell. Adjust poles as necessary to provide a permanent vertical position with the bracket arm in proper position for luminaire location.

3.1.2 Pole Setting

Depth shall be as indicated. Poles in straight runs shall be in a straight line. Dig holes large enough to permit the proper use of tampers to the full depth of the hole. Place backfill in the hole in 6 inch maximum layers and thoroughly tamp. Place surplus earth around the pole in a conical shape and pack tightly to drain water away.

3.1.3 GROUNDING

Ground noncurrent-carrying parts of equipment including metal poles, luminaires, mounting arms, brackets, and metallic enclosures as specified in Section 16302UNDERGROUND ELECTRICAL DISTRIBUTION SYSTEM. Where copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.

3.1.4 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting shall be as specified in Section 09900 PAINTS AND COATINGS.

3.2 FIELD QUALITY CONTROL

Upon completion of installation, verify that equipment is properly installed, connected, and adjusted. Conduct an operating test to show that the equipment operates in accordance with the requirements of this section.

-- End of Section --

SECTION 16710
BUILDING TELECOMMUNICATIONS CABLING SYSTEM
01/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE Std 100	(2000) The Authoritave Dictionary of IEEE Standards Terms

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-83-596	(2001) Fiber Optic Premises Distribution Cable
ICEA S-90-661	(2002) Category 3, 5, & 5e Individually Unshielded Twisted Pair Indoor Cable for Use in General Purpose and LAN Communications Wiring Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA WC 63.1	(2005) Twisted Pair Premise Voice and Data Communications Cables
NEMA WC 66	(2001; Errata 2003) Category 6 and Category 7 100 Ohm Shielded and Unshielded Twisted Pairs

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2007) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA J-STD-607-A	(2002) Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
TIA-526-7	(2002) Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant OFSTP-7
TIA/EIA-568-B.1	(2001 Addendums 2001, 2003, 2003, 2003, 2004, 2007) Commercial Building Telecommunications Cabling Standard - Part 1: General Requirements
TIA/EIA-568-B.2	(2001) Commercial Building Telecommunications Cabling Standard – Part

	2: Balanced Twisted Pair Cabling Components
TIA/EIA-568-B.3	(2000; Addendum 2002) Optical Fiber Cabling Components Standard
TIA/EIA-569-A	(1998; Addenda 2000, 2001) Commercial Building Standards for Telecommunications Pathways and Spaces
TIA/EIA-598-B	(2001) Optical Fiber Calbe Color Coding
TIA/EIA-606-A	(2002) Administration Standard for the Telecommunications Infrastructure

UNDERWRITERS LABORATORIES (UL)

UL 1286	(1999; Rev thru Jul 2004) Office Furnishings
UL 1666	(2007) Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts
UL 444	(2002; Rev thru Sep 2006) Communications Cables
UL 467	(2007) Standard for Grounding and Bonding Equipment
UL 910	(1998) Test for Flame-Propagation and Smoke-Density Values for Electrical and Optical-Fiber Cables Used in Spaces Transporting Environmental Air
UL 969	(1995; Rev thru Dec 2006) Marking and Labeling Systems

1.2 RELATED REQUIREMENTS

Section 16402 INTERIOR DISTRIBUTION SYSTEM and Section 16711 TELECOMMUNICATIONS, OUTSIDE PLANT, apply to this section with additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in this specification shall be as defined in TIA/EIA-568-B.1, TIA/EIA-568-B.2, TIA/EIA-568-B.3, TIA/EIA-569-A, TIA/EIA-606-A and IEEE Std 100 and herein.

1.3.1 Campus Distributor (CD)

A distributor from which the campus backbone cabling emanates. (International expression for main cross-connect (MC).)

1.3.2 Building Distributor (BD)

A distributor in which the building backbone cables terminate and at which connections to the campus backbone cables may be made. (International expression for intermediate cross-connect (IC).)

1.3.3 Floor Distributor (FD)

A distributor used to connect horizontal cable and cabling subsystems or equipment. (International expression for horizontal cross-connect (HC).)

1.3.4 Telecommunications Room (TR)

An enclosed space for housing telecommunications equipment, cable, terminations, and cross-connects. The room is the recognized cross-connect between the backbone cable and the horizontal cabling.

1.3.5 Entrance Facility (EF) (Telecommunications)

An entrance to the building for both private and public network service cables (including antennae) including the entrance point at the building wall and continuing to the entrance room or space.

1.3.6 Entrance Room (ER) (Telecommunications)

A centralized space for telecommunications equipment that serves the occupants of a building. Equipment housed therein is considered distinct from a telecommunications room because of the nature of its complexity.

1.3.7 Open Cable

Cabling that is not run in a raceway as defined by NFPA 70. This refers to cabling that is "open" to the space in which the cable has been installed and is therefore exposed to the environmental conditions associated with that space.

1.3.8 Open Office

A floor space division provided by furniture, moveable partitions, or other means instead of by building walls.

1.3.9 Pathway

A physical infrastructure utilized for the placement and routing of telecommunications cable.

1.4 SYSTEM DESCRIPTION

The building telecommunications cabling and pathway system shall include permanently installed backbone and horizontal cabling, horizontal and backbone pathways, service entrance facilities, work area pathways, telecommunications outlet assemblies, conduit, raceway, and hardware for splicing, terminating, and interconnecting cabling necessary to transport telephone and data (including LAN) between equipment items in a building. The horizontal system shall be wired in a star topology from the telecommunications work area to the floor distributor or campus distributor at the center or hub of the star. The backbone cabling and pathway system includes intrabuilding and interbuilding interconnecting cabling, pathway, and terminal hardware. The intrabuilding backbone provides connectivity from the floor distributors to the building distributors or to the campus distributor and from the building distributors to the campus distributor as required. The backbone system shall be wired in a star topology with the campus distributor at the center or hub of the star. The interbuilding backbone system provides connectivity between the campus distributors and is specified in Section 16711 TELECOMMUNICATIONS OUTSIDE PLANT. Provide telecommunications pathway systems referenced herein as specified in Section 16402 INTERIOR DISTRIBUTION SYSTEM. The telecommunications contractor must coordinate with the NMCI contractor concerning access to and configuration of telecommunications spaces. The telecommunications contractor may be required to coordinate work effort within the telecommunications spaces with the NMCI contractor.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Telecommunications drawings; G

Telecommunications Space Drawings; G

In addition to Section 01330 SUBMITTAL PROCEDURES, provide shop drawings in accordance with paragraph SHOP DRAWINGS.

SD-03 Product Data

Telecommunications cabling (backbone and horizontal); G
Submittals shall include the manufacturer's name, trade name, place of manufacture, and catalog model or number. Include performance and characteristic curves. Submittals shall also include applicable federal, military, industry, and technical society publication references. Should manufacturer's data require supplemental information for clarification, the supplemental information shall be submitted as specified in paragraph REGULATORY REQUIREMENTS and as required in Section 01330 SUBMITTAL PROCEDURES.

SD-06 Test Reports

Telecommunications cabling testing; G

SD-07 Certificates

Telecommunications Contractor Qualifications; G

Key Personnel Qualifications; G

Manufacturer Qualifications; G

Test plan; G

SD-09 Manufacturer's Field Reports

Factory reel tests; G

SD-10 Operation and Maintenance Data

Telecommunications cabling and pathway system Data Package 5; G

SD-11 Closeout Submittals

Record Documentation; G

1.6 QUALITY ASSURANCE

1.6.1 Shop Drawings

In exception to Section 01300 SUBMITTAL PROCEDURES, submit shop drawings a minimum of 14 by 20 inches in size using a minimum scale of 1/8 inch per foot[, except as specified otherwise]. Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Submittals shall include the nameplate data, size, and capacity. Submittals shall also include applicable federal, military, industry, and technical society publication references.

1.6.1.1 Telecommunications Drawings

Provide[registered communications distribution designer (RCDD) approved,] drawings in accordance with TIA/EIA-606-A. The identifier for each termination and cable shall appear on the drawings. Drawings shall depict final telecommunications installed wiring system infrastructure in accordance with TIA/EIA-606-A. The drawings should provide details required to prove that the distribution system shall properly support connectivity from the EF telecommunications and ER telecommunications, CD's[, BD's], and FD's to the telecommunications work area outlets.[Provide a plastic laminated schematic of the as-installed telecommunications cable system showing cabling, CD's, BD's, FD's, and the EF and ER for telecommunications keyed to floor plans by room number. Mount the laminated schematic in the EF telecommunications space as directed by the Contracting Officer.] The following drawings shall be provided as a minimum:

a. T1 - Layout of complete building per floor - Building Area/Serving Zone Boundaries, Backbone Systems, and Horizontal Pathways. Layout of complete building per floor. The drawing indicates location of building areas, serving zones, vertical backbone diagrams, telecommunications rooms, access points, pathways, grounding system, and other systems that need to be viewed from the complete building perspective.

b. T2 - Serving Zones/Building Area Drawings - Drop Locations and Cable Identification (ID’S). Shows a building area or serving zone. These drawings show drop locations, telecommunications rooms, access points and detail call outs for common equipment rooms and other congested areas.

c. T4 - Typical Detail Drawings - Faceplate Labeling, Firestopping, Americans with Disabilities Act (ADA), Safety, Department of Transportation (DOT). Detailed drawings of symbols and typical such as faceplate labeling, faceplate types, faceplate population installation procedures, detail racking, and raceways.

1.6.1.2 Telecommunications Space Drawings

Provide T3 drawings in accordance with TIA/EIA-606-A that include telecommunications rooms plan views, pathway layout (cable tray, racks, ladder-racks, etc.), mechanical/electrical layout, and [cabinet][, rack][, backboard][and] wall elevations. Drawings shall show layout of applicable equipment including incoming cable stub or connector blocks, building protector assembly, outgoing cable connector blocks, patch panels and equipment spaces and cabinet/racks. Drawings shall include a complete list of equipment and material, equipment rack details, proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearance for maintenance and operation. Drawings may also be an enlargement of a congested area of T1 or T2 drawings.

1.6.2 Telecommunications Qualifications

Work under this section shall be performed by and the equipment shall be provided by the approved telecommunications contractor and key personnel. Qualifications shall be provided for: the telecommunications system contractor, the telecommunications system installer, and the supervisor (if different from the installer). A minimum of 30 days prior to installation, submit documentation of the experience of the telecommunications contractor and of the key personnel.

1.6.2.1 Telecommunications Contractor

The telecommunications contractor shall be a firm which is regularly and professionally engaged in the business of the applications, installation, and testing of the specified telecommunications systems and equipment. The telecommunications contractor shall demonstrate experience in providing successful telecommunications systems within the past 3 years. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for the telecommunications contractor.

1.6.2.2 Key Personnel

Provide key personnel who are regularly and professionally engaged in the business of the application, installation and testing of the specified telecommunications systems and equipment. There may be one key person or more key persons proposed for this solicitation depending upon how many of the key roles each has successfully provided. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems within the past 3 years.

Supervisors and installers assigned to the installation of this system or any of its components shall be Building Industry Consulting Services International (BICSI) Registered Cabling Installers, Technician Level. Submit documentation of current BICSI certification for each of the key personnel.

In lieu of BICSI certification, supervisors and installers assigned to the installation of this system or any of its components shall have a minimum of 3 years experience in the installation of the specified copper and fiber optic cable and components. They shall have factory or factory approved certification from each equipment manufacturer indicating that they are qualified to install and test the provided products. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for each of the key personnel. Documentation for each key person shall include at least two successful system installations provided that are equivalent in system size and in construction complexity to the telecommunications system proposed for this solicitation. Include specific experience in installing and testing telecommunications systems and provide the names and locations of at least two project installations successfully completed using optical fiber and copper telecommunications cabling systems. All of the existing telecommunications system installations offered by the key persons as successful experience shall have been in successful full-time service for at least 18 months prior to the issuance date for this solicitation. Provide the name and role of the key person, the title, location, and completed installation date of the referenced project, the referenced project owner point of contact information including name, organization, title, and telephone number, and generally, the referenced project description including system size and construction complexity.

Indicate that all key persons are currently employed by the telecommunications contractor, or have a commitment to the telecommunications contractor to work on this project. All key persons shall be employed by the telecommunications contractor at the date of issuance of this solicitation, or if not, have a commitment to the telecommunications contractor to work on this project by the date that the bid was due to the Contracting Officer.

Note that only the key personnel approved by the Contracting Officer in the successful proposal shall do work on this solicitation's telecommunications system. Key personnel shall function in the same roles in this contract, as they functioned in the offered successful experience. Any substitutions for the telecommunications contractor's key personnel requires approval from The Contracting Officer.

1.6.2.3 Minimum Manufacturer Qualifications

Cabling, equipment and hardware manufacturers shall have a minimum of 3 years experience in the manufacturing, assembly, and factory testing of components which comply with TIA/EIA-568-B.1, TIA/EIA-568-B.2 and TIA/EIA-568-B.3.

1.6.3 Test Plan

Provide a complete and detailed test plan for the telecommunications cabling system including a complete list of test equipment for the UTP and optical fiber components and accessories 60 days prior to the proposed test date. Include procedures for certification, validation, and testing.

1.6.4 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.6.5 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.6.5.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.6.5.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.7 DELIVERY AND STORAGE

Provide protection from weather, moisture, extreme heat and cold, dirt, dust, and other contaminants for telecommunications cabling and equipment placed in storage.

1.8 ENVIRONMENTAL REQUIREMENTS

Connecting hardware shall be rated for operation under ambient conditions of 32 to 140 degrees F and in the range of 0 to 95 percent relative humidity, noncondensing.

1.9 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.10 MAINTENANCE

1.10.1 Operation and Maintenance Manuals

Commercial off the shelf manuals shall be furnished for operation, installation, configuration, and maintenance of products provided as a part of the telecommunications cabling and pathway system. Submit operations and maintenance data in accordance with Section 017813 OPERATION AND MAINTENANCE DATA and as specified herein not later than 2 months prior to the date of beneficial occupancy. In addition to requirements of Data package 5, include the requirements of paragraphs TELECOMMUNICATIONS DRAWINGS, TELECOMMUNICATIONS SPACE DRAWINGS, and RECORD DOCUMENTATION.

1.10.2 Record Documentation

Provide T5 drawings including documentation on cables and termination hardware in accordance with TIA/EIA-606-A. T5 drawings shall include schedules to show information for cut-overs and cable plant management, patch panel layouts and cover plate assignments, cross-connect information and connecting terminal layout as a minimum. T5 drawings shall be provided on electronic media using Windows based computer cable management software. A licensed copy of the cable management software including documentation, shall be provided. Provide the following T5 drawing documentation as a minimum:

a. Cables - A record of installed cable shall be provided in accordance with TIA/EIA-606-A. The cable records shall include the required data fields for each cable and complete end-to-end circuit report for each complete circuit from the assigned outlet to the entry facility in accordance with TIA/EIA-606-A. Include manufacture date of cable with submittal.

b. Termination Hardware - A record of installed patch panels, cross-connect points, distribution frames, terminating block arrangements and type, and outlets shall be provided in accordance with TIA/EIA-606-A. Documentation shall include the required data fields as a minimum in accordance with TIA/EIA-606-A.

PART 2 PRODUCTS

2.1 COMPONENTS

UL or third party certified. Where equipment or materials are specified to conform to industry and technical society reference standards of the organizations, submit proof of such compliance. The label or listing by the specified organization will be acceptable evidence of compliance. In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Contracting Officer. The certificate shall state that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard. Provide a complete system of telecommunications cabling and pathway components using star topology. Provide support structures and pathways, complete with outlets, cables, connecting hardware and telecommunications cabinets/racks. Cabling and interconnecting hardware and components for telecommunications systems shall be UL listed or third party independent testing laboratory certified, and shall comply with NFPA 70 and conform to the requirements specified herein.

2.2 TELECOMMUNICATIONS PATHWAY

Provide telecommunications pathways in accordance with TIA/EIA-569-A and as specified in Section 16402 INTERIOR DISTRIBUTION SYSTEM. Provide system furniture pathways in accordance with UL 1286.

2.3 TELECOMMUNICATIONS CABLING

Cabling shall be UL listed for the application and shall comply with TIA/EIA-568-B.1 , TIA/EIA-568-B.2, TIA/EIA-568-B.3 and NFPA 70. Provide a labeling system for cabling as required by TIA/EIA-606-A and UL 969. Ship cable on reels bearing manufacture date for UTP in accordance with ICEA S-90-661 and optical fiber cables in accordance with ICEA S-83-596 for all cable used on this project. Cabling manufactured more than 12 months prior to date of installation shall not be used.

2.3.1 Backbone Cabling

2.3.1.1 Backbone Copper

ICEA S-90-661, TIA/EIA-568-B.1, TIA/EIA-568-B.2, NEMA WC 63.1 NEMA WC 66 and UL 444, copper backbone cable shall be solid conductor, 22 AWG, 100 ohm, 100-pair UTP (Unshielded twisted pair), formed into 25 pair binder groups covered with a gray thermoplastic jacket and overall metallic shield. Cable shall be imprinted with manufacturers name or identifier, flammability rating, gauge of conductor, transmission performance rating (category designation) at regular intervals not to exceed 2 feet. The word "FEET" or the abbreviation "FT" shall appear after each length marking. Provide communications general purpose (CM or CMG), communications plenum (CMP) or communications riser (CMR) rated cabling in accordance with NFPA 70. Type CMP and CMR may be substituted for type CM or CMG and type CMP may be substituted for type CMR in accordance with NFPA 70. Color coding shall comply with industry standards for 25 pair cables.

2.3.1.2 Backbone Optical Fiber

Provide in accordance with ICEA S-83-596, TIA/EIA-568-B.3, UL 1666 and NFPA 70. Cable shall be imprinted with fiber count, fiber type and aggregate length at regular intervals not to exceed 40 inches.
Provide nonconductive optical fiber general purpose cable (OFN or OFNG), nonconductive optical fiber plenum cable (OFNP), and nonconductive optical fiber riser cable (OFNR) rated cable in accordance with NFPA 70 and UL 910. Type OFNP or OFNR may be substituted for type OFN or OFNG and type OFNP may be substituted for type OFNR in accordance with NFPA 70. The cable cordage jacket, fiber, unit, and group color shall be in accordance with TIA/EIA-598-B.

]2.3.2 Horizontal Cabling

Provide horizontal cable in compliance with NFPA 70 and performance characteristics in accordance with TIA/EIA-568-B.1.

2.3.2.1 Horizontal Copper

Provide horizontal copper cable in accordance with TIA/EIA-568-B.2, UL 444, NEMA WC 63.1 NEMA WC 66, ICEA S-90-661 UTP (unshielded twisted pair), 100 ohm. Provide four each individually twisted pair, 22 AWG conductors, Category 6, with a blue thermoplastic jacket. Cable shall be imprinted with manufacturers name or identifier, flammability rating, gauge of conductor, transmission performance rating (category designation) at regular intervals not to exceed 2 feet. The word "FEET" or the abbreviation "FT" shall appear after each length marking. Provide communications general purpose (CM or CMG), communications plenum (CMP) or communications riser (CMR) rated cabling in accordance with NFPA 70. Type CMP and CMR may be substituted for type CM or CMG and type CMP may be substituted for type CMR in accordance with NFPA 70.

2.3.2.2 Horizontal Optical Fiber

Provide optical fiber horizontal cable in accordance with ICEA S-83-596, TIA/EIA-568-B.3 and single-mode, 8/125-um diameter, 0.10 numerical aperture, tight buffered fiber optic cables. Cable shall be imprinted with manufacturer, flammability rating and fiber count at regular intervals not to exceed 40 inches. Provide nonconductive optical fiber general purpose cable (OFN or OFNG), nonconductive optical fiber riser cable (OFNR) or nonconductive optical fiber plenum cable (OFNP) in accordance with NFPA 70. Type OFNP or OFNR may be substituted for type OFN or OFNG and type OFNP may be substituted for type OFNR in accordance with NFPA 70. The cable jacket shall be of single jacket construction with color coding of cordage jacket, fiber, unit, and group in accordance with TIA/EIA-598-B.

2.3.3 Work Area Cabling

2.3.3.1 Work Area Copper

Provide work area copper cable in accordance with TIA/EIA-568-B.2, with a blue, thermoplastic jacket.

2.3.3.2 Work Area Optical Fiber

Provide optical work area cable in accordance with TIA/EIA-568-B.3.

2.4 TELECOMMUNICATIONS SPACES

Provide connecting hardware and termination equipment in the telecommunications entrance facility and telecommunication equipment rooms to facilitate installation as shown on design drawings for terminating and cross-connecting permanent cabling. Provide telecommunications interconnecting hardware color coding in accordance with TIA/EIA-606-A.

2.4.1 Backboards

Provide void-free, interior grade plywood 3/4 inch thick 4 by 8 feet. Backboards shall be fire rated. Backboards shall be provided on a minimum of two walls in the telecommunication spaces. Do not cover the fire stamp on the backboard.

2.5 GROUNDING AND BONDING PRODUCTS

Provide in accordance with UL 467, TIA J-STD-607-A, and NFPA 70. Components shall be identified as required by TIA/EIA-606-A. Provide ground rods, bonding conductors, and grounding busbars as specified in Section 16402 INTERIOR DISTRIBUTION SYSTEM.

2.6 FIRESTOPPING MATERIAL

Provide as specified in Section 07840 FIRESTOPPING.

2.7 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.8 TESTS, INSPECTIONS, AND VERIFICATIONS

2.8.1 Factory Reel Tests

Provide documentation of the testing and verification actions taken by manufacturer to confirm compliance with TIA/EIA-568-B.1, TIA/EIA-568-B.3, TIA-526-7 for single mode optical fiber cables.

PART 3 EXECUTION

3.1 INSTALLATION

Install telecommunications cabling and pathway systems, including the horizontal and backbone cable, pathway systems, telecommunications outlet/connector assemblies, and associated hardware in accordance with TIA/EIA-568-B.1, TIA/EIA-568-B.2, TIA/EIA-568-B.3, TIA/EIA-569-A, NFPA 70, and UL standards as applicable. Provide cabling in a star topology network. Pathways and outlet boxes shall be installed as specified in Section 16402 INTERIOR DISTRIBUTION SYSTEM. Install telecommunications cabling with copper media in accordance with the following criteria to avoid potential electromagnetic interference between power and telecommunications equipment. The interference ceiling shall not exceed 3.0 volts per meter measured over the usable bandwidth of the telecommunications cabling. Cabling shall be run with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.

3.1.1 Cabling

Install Category 6 UTP, and optical fiber telecommunications cabling system as detailed in TIA/EIA-568-B.1, TIA/EIA-568-B.2, and TIA/EIA-568-B.3. Screw terminals shall not be used except where specifically indicated on plans. Use an approved insulation displacement connection (IDC) tool kit for copper cable terminations. Do not untwist Category 6 UTP cables more than one half inch from the point of termination to maintain cable geometry. Provide service loop on each end of the cable, 10 ft. in the telecommunications room, and 12 inches in the work area outlet. Do not exceed manufacturers' cable pull tensions for copper and optical fiber cables. Provide a device to monitor cable pull tensions. Do not exceed 25 pounds pull tension for four pair copper cables. Do not chafe or damage outer jacket materials. Use only lubricants approved by cable manufacturer. Do not over cinch cables, or crush cables with staples. For UTP cable, bend radii shall not be less than four times the cable diameter. Cables shall be terminated; no cable shall contain unterminated elements. Cables shall not be spliced. Label cabling in accordance with paragraph LABELING in this section.

3.1.1.1 Open Cable

Use only where specifically indicated on plans for use in cable trays, or below raised floors. Install in accordance with TIA/EIA-568-B.1, TIA/EIA-568-B.2 and TIA/EIA-568-B.3. Do not exceed cable pull tensions recommended by the manufacturer. Copper cable not in a wireway or pathway shall be suspended a minimum of 8 inches above ceilings by cable supports no greater than 60 inches apart. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items. Placement of cable parallel to power conductors shall be avoided, if possible; a minimum separation of 12 inches shall be maintained when such placement cannot be avoided.

a. Plenum cable shall be used where open cables are routed through plenum areas. Cable routed exposed under raised floors shall be plenum rated. Plenum cables shall comply with flammability plenum requirements of NFPA 70. Install cabling after the flooring system has been installed in raised floor areas. Cable 6 feet long shall be neatly coiled not less than 12 inches in diameter below each feed point in raised floor areas.

]3.1.1.2 Backbone Cable

a. Copper Backbone Cable. Install intrabuilding backbone copper cable, in indicated pathways, between the campus distributor, located in the telecommunications entrance facility or room, the building distributors and the floor distributors located in telecommunications rooms and telecommunications equipment rooms as indicated on drawings.

b. Optical fiber Backbone Cable. Install intrabuilding backbone optical fiber in indicated pathways. Do not exceed manufacturer's recommended bending radii and pull tension. Prepare cable for pulling by cutting outer jacket 10 inches leaving strength members exposed for approximately 10 inches. Twist strength members together and attach to pulling eye. Vertical cable support intervals shall be in accordance with manufacturer's recommendations.

3.1.1.3 Horizontal Cabling

Install horizontal cabling as indicated on drawings between the campus distributor, building distributors, floor distributors, MUTOA and the telecommunications outlet assemblies at workstations.

3.1.2 Pathway Installations

Provide in accordance with TIA/EIA-569-A and NFPA 70. Provide building pathway as specified in Section 16402 INTERIOR DISTRIBUTION SYSTEMS.

3.1.3 Service Entrance Conduit, Underground

Provide service entrance underground as specified in Section 16402 INTERIOR DISTRIBUTION SYSTEMS.

3.1.4 Work Area Outlets

3.1.4.1 Terminations

Terminate UTP cable in accordance with TIA/EIA-568-B.1, TIA/EIA-568-B.2 and wiring configuration as specified. Terminate fiber optic cables in accordance with TIA/EIA-568-B.3

3.1.4.2 Cover Plates

As a minimum, each outlet/connector shall be labeled as to its function and a unique number to identify cable link in accordance with the paragraph LABELING in this section.

3.1.4.3 Cables

Unshielded twisted pair and fiber optic cables shall have a minimum of 12 inches of slack cable loosely coiled into the telecommunications outlet boxes. Minimum manufacturer's bend radius for each type of cable shall not be exceeded.

3.1.4.4 Pull Cords

Pull cords shall be installed in conduit serving telecommunications outlets that do not have cable installed.

3.1.4.5 Multi-User Telecommunications Outlet Assembly (MUTOA)

Run horizontal cable in the ceiling or underneath the floor and terminate each cable on a MUTOA in each individual zone. MUTOAs shall not be located in ceiling spaces, or any obstructed area. MUTOAs shall not be installed in furniture unless that unit of furniture is permanently secured to the building structure. MUTOAs shall be located in an open work area so that each furniture cluster is served by at least one MUTOA. The MUTOA shall be limited to serving a maximum of twelve work areas. Maximum work area cable length requirements shall also be taken into account. MUTOAs must be labeled to include the maximum length of work area cables. MUTOA labeling is in addition to the labeling described in TIA/EIA-606-A, or other applicable cabling administration standards. Work area cables extending from the MUTOA to the work area device must also be uniquely identified and labeled.

3.1.5 Telecommunications Space Termination

Install termination hardware required for Category 6 and optical fiber system. An insulation displacement tool shall be used for terminating copper cable to insulation displacement connectors.

3.1.6 Electrical Penetrations

Seal openings around electrical penetrations through fire resistance-rated wall, partitions, floors, or ceilings as specified in Section 07840 FIRESTOPPING.

3.2 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting shall be as specified in Section 09900 PAINTS AND COATINGS.

3.3 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.4 TESTING

3.4.1 Telecommunications Cabling Testing

Perform telecommunications cabling inspection, verification, and performance tests in accordance with TIA/EIA-568-B.1, TIA/EIA-568-B.2, TIA/EIA-568-B.3. Perform optical fiber field inspection tests via attenuation measurements on factory reels and provide results along with manufacturer certification for factory reel tests. Remove failed cable reels from project site upon attenuation test failure.

3.4.1.1 Inspection
Visually inspect UTP and optical fiber jacket materials for UL or third party certification markings. Inspect cabling terminations in telecommunications rooms and at workstations to confirm color code for T568A or T568B pin assignments, and inspect cabling connections to confirm compliance with TIA/EIA-568-B.1, TIA/EIA-568-B.2, and TIA/EIA-568-B.3, . Visually confirm Category 6, marking of outlets, cover plates,

outlet/connectors, and patch panels.

3.4.1.2 Verification Tests

UTP backbone copper cabling shall be tested for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors, and between conductors and shield, if cable has overall shield. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connected.

For single-mode optical fiber, perform optical fiber end-to-end attenuation tests in accordance with TIA/EIA-568-B.3 and TIA-526-7 using Method B, OTDR for single-mode optical fiber. Perform verification acceptance tests.

3.4.1.3 Performance Tests

Perform testing for each outlet and MUTOA as follows:

a. Perform Category 6 link tests in accordance with TIA/EIA-568-B.1 and TIA/EIA-568-B.2. Tests shall include wire map, length, insertion loss, NEXT, PSNEXT, ELFEXT, PSELFEXT, return loss, propagation delay, and delay skew.

b. Optical fiber Links. Perform optical fiber end-to-end link tests in accordance with TIA/EIA-568-B.3.

-- End of Section –

SECTION 16711
TELECOMMUNICATIONS OUTSIDE PLANT (OSP)
04/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM B 1	(2001; R 2007) Standard Specification for Hard-Drawn Copper Wire
ASTM B 8	(2004) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM D 709	(2001; R 2007) Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2007; Errata 2007) National Electrical Safety Code
IEEE Std 100	(2000) The Authoritave Dictionary of IEEE Standards Terms

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-87-640	(2006) Fiber Optic Outside Plant Communications Cable
ICEA S-98-688	(2006) Broadband Twisted Pair, Telecommunications Cable Aircore, Polyolefin Insulated Copper Conductors
ICEA S-99-689	(2006) Broadband Twisted Pair Telecommunications Cable Filled, Polyolefin Insulated Copper Conductors

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA C62.61	(1993) Gas Tube Surge Arresters on Wire Line Telephone Circuits

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2007) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA J-STD-607-A	(2002) Commercial Building Grounding

	(Earthing) and Bonding Requirements for Telecommunications
TIA-455-107A	(1999) Component Reflectance or Link/System Return Loss using a Loss Test Set
TIA-455-46A	(1990) FOTP-46 Spectral Attenuation Measurement for Long-Length, Graded-Index Optical Fibers
TIA-455-78-B	(2002) FOTP-78 Optical Fibres - Part 1-40: Measurement Methods and Test Procedures – Attenuation
TIA-492E000	(1996; R 2002) Class IVd Nonzero-Dispersion Single-Mode Optical Fibers for the 1550 nm Window (ANSI/TIA/EIA-492E000)
TIA-526-14-A	(1998) OFSTP-14A Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant
TIA-526-7	(2002) Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant OFSTP-7
TIA-590-A	(1997) Standard for Physical Location and Protection of Below Ground Fiber Optic Cable Plant
TIA-758-A	(2004) Customer-Owned Outside Plant Telecommunications Cabling Standard
TIA/EIA-455-B	(1998) Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and other Fiber Optic Components
TIA/EIA-568-B.1	(2001 Addendums 2001, 2003, 2003, 2003, 2004, 2007) Commercial Building Telecommunications Cabling Standard - Part 1: General Requirements
TIA/EIA-568-B.2	(2001) Commercial Building Telecommunications Cabling Standard - Part 2: Balanced Twisted Pair Cabling Components
TIA/EIA-568-B.3	(2000; Addendum 2002) Optical Fiber Cabling Components Standard
TIA/EIA-569-A	(1998; Addenda 2000, 2001) Commercial Building Standards for Telecommunications Pathways and Spaces
TIA/EIA-598-B	(2001) Optical Fiber Calbe Color Coding
TIA/EIA-606-A	(2002) Administration Standard for the

Telecommunications Infrastructure

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS 1755	Telecommunications Standards and Specifications for Materials, Equipment and Construction
RUS Bull 1751F-640	(1995) Design of Buried Plant, Physical Considerations
RUS Bull 1751F-815	(1979) Electrical Protection of Outside Plant
RUS Bull 1753F-201	(1997) Acceptance Tests of Telecommunications Plant (PC-4)
RUS Bull 1753F-401	(1995) Splicing Copper and Fiber Optic Cables (PC-2)
RUS Bull 345-50	(1979) Trunk Carrier Systems (PE-60)
RUS Bull 345-65	(1985) Shield Bonding Connectors (PE-65)
RUS Bull 345-72	(1985) Filled Splice Closures (PE-74)
RUS Bull 345-83	(1979; Rev Oct 1982) Gas Tube Surge Arrestors (PE-80)

UNDERWRITERS LABORATORIES (UL)

UL 497	(2001; Rev thru Jun 2004) Protectors for Paired Conductor Communication Circuits
UL 510	(2005; Rev thru Aug 2005) Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape
UL 83	(2003; Rev thru Apr 2006) Standard for Thermoplastic-Insulated Wires and Cables

1.2 RELATED REQUIREMENTS

Section 16710 BUILDING TELECOMMUNICATIONS CABLING SYSTEM and Section 16302 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND apply to this section with additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in this specification shall be as defined in TIA/EIA-568-B.1, TIA/EIA-568-B.2, TIA/EIA-568-B.3, TIA/EIA-569-A, TIA/EIA-606-A, and IEEE Std 100 and herein.

1.3.1 Campus Distributor (CD)

A distributor from which the campus backbone cabling emanates. (International expression for main cross-connect - (MC).)

1.3.2 Entrance Facility (EF) (Telecommunications)

An entrance to the building for both private and public network service cables (including antennae) including the entrance point at the building wall and continuing to the entrance room or space.

1.3.3 Entrance Room (ER) (Telecommunications)

A centralized space for telecommunications equipment that serves the occupants of a building. Equipment housed therein is considered distinct from a telecommunications room because of the nature of its complexity.

1.3.4 Building Distributor (BD)

A distributor in which the building backbone cables terminate and at which connections to the campus backbone cables may be made. (International expression for intermediate cross-connect - (IC).)

1.3.5 Pathway

A physical infrastructure utilized for the placement and routing of telecommunications cable.

1.4 SYSTEM DESCRIPTION

The telecommunications outside plant consist of cable, conduit, & manholes to provide a diverse redundant fiber optic tie between the Operations and MOD-2 Buildings, and a diverse redundant copper tie between the Operations Building and communications hut located near the corner of 15th Street and Lane Avenue. The work consists of providing, terminating, and testing of the cables above.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Telecommunications Outside Plant; G

Telecommunications Entrance Facility Drawings; G

In addition to Section 01330 SUBMITTAL PROCEDURES, provide shop drawings in accordance with paragraph SHOP DRAWINGS.

SD-03 Product Data

Wire and cable; G

Cable splices, and connectors; G

Closures; G

Building protector assemblies; G

Protector modules; G

Cross-connect terminal cabinets; G

Spare Parts; G

Submittals shall include the manufacturer's name, trade name, place of manufacture, and catalog model or number. Should manufacturer's data require supplemental information for clarification, the supplemental information shall be submitted as specified in paragraph REGULATORY REQUIREMENTS and as required for certificates in Section 01330 SUBMITTAL PROCEDURES.

SD-06 Test Reports

Pre-installation tests; G

Acceptance tests; G

Outside Plant Test Plan; G

SD-07 Certificates

Telecommunications Contractor Qualifications; G

Key Personnel Qualifications; G

Minimum Manufacturer's Qualifications; G

SD-08 Manufacturer's Instructions

Building protector assembly installation; G

Cable tensions; G

Fiber Optic Splices; G

Submit instructions prior to installation.

SD-09 Manufacturer's Field Reports

Factory Reel Test Data; G

SD-10 Operation and Maintenance Data

Telecommunications outside plant (OSP), Data Package 5; G

Commercial off-the-shelf manuals shall be provided for operation, installation, configuration, and maintenance of products provided as a part of the telecommunications outside plant (OSP). Submit operations and maintenance data in accordance with Section 01781 OPERATION AND MAINTENANCE DATA and as specified herein not later than 2 months prior to the date of beneficial occupancy. In addition to requirements of Data package 5, include the requirements of paragraphs TELECOMMUNICATIONS OUTSIDE PLANT SHOP DRAWINGS and TELECOMMUNICATIONS ENTRANCE FACILITY DRAWINGS.

SD-11 Closeout Submittals

Record Documentation; G

In addition to other requirements, provide in accordance with paragraph RECORD DOCUMENTATION.

1.6 QUALITY ASSURANCE

1.6.1 Shop Drawings

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Submittals shall include the nameplate data, size, and capacity.

1.6.1.1 Telecommunications Outside Plant Shop Drawings

Provide Outside Plant Design in accordance with TIA-758-A. Provide T0 shop drawings that show the physical and logical connections from the perspective of an entire campus, such as actual building locations, exterior pathways and campus backbone cabling on plan view drawings, major system nodes, and related connections on the logical system drawings in accordance with TIA/EIA-606-A. Drawings shall include wiring and schematic diagrams for fiber optic and copper cabling and splices, copper conductor gauge and pair count, fiber pair count and type, pathway duct and innerduct arrangement, associated construction materials, and any details required to demonstrate that cable system has been coordinated Provide Registered Communications Distribution Designer (RCDD) approved drawings of the telecommunications outside plant.][Update existing telecommunication Outside Plant T0 drawings to include information modified, deleted or added as a result of this installation in accordance with TIA/EIA-606-A.] The telecommunications outside plant (OSP) shop drawings shall be included in the operation and maintenance manuals.

1.6.1.2 Telecommunications Entrance Facility Drawings

Provide T3 drawings for EF Telecommunications in accordance with TIA/EIA-606-A that include telecommunications entrance facility plan views, pathway layout (cable tray, racks, ladder-racks, etc.), and cabinet, rack, backboard and wall elevations. Drawings shall show layout of applicable equipment including incoming cable, building protector assembly, . Drawings shall include a complete list of equipment and material, equipment rack details, proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearance for maintenance and operation. Drawings may also be an enlargement of a congested area of T1 or T2 drawings. The telecommunications entrance facility shop drawings shall be included in the operation and maintenance manuals.

1.6.2 Telecommunications Qualifications

Work under this section shall be performed by and the equipment shall be provided by the approved telecommunications contractor and key personnel. Qualifications shall be provided for: the telecommunications system contractor, the telecommunications system installer, the supervisor (if different from the installer), and the cable splicing and terminating

personnel. A minimum of 30 days prior to installation, submit documentation of the experience of the telecommunications contractor and of the key personnel.

1.6.2.1 Telecommunications Contractor Qualifications

The telecommunications contractor shall be a firm which is regularly and professionally engaged in the business of the applications, installation, and testing of the specified telecommunications systems and equipment. The telecommunications contractor shall demonstrate experience in providing successful telecommunications systems that include outside plant and broadband cabling within the past 3 years. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for the telecommunications contractor. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems in accordance with TIA-758-A within the past 3 years.

1.6.2.2 Key Personnel Qualifications

Provide key personnel who are regularly and professionally engaged in the business of the application, installation and testing of the specified telecommunications systems and equipment. There may be one key person or more key persons proposed for this solicitation depending upon how many of the key roles each has successfully provided. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems within the past 3 years.

Cable splicing and terminating personnel assigned to the installation of this system or any of its components shall have training in the proper techniques and have a minimum of 3 years experience in splicing and terminating the specified cables. Modular splices shall be performed by factory certified personnel or under direct supervision of factory trained personnel for products used.

Supervisors and installers assigned to the installation of this system or any of its components shall have factory or factory approved certification from each equipment manufacturer indicating that they are qualified to install and test the provided products.

Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for each of the key personnel. Documentation for each key person shall include at least two successful system installations provided that are equivalent in system size and in construction complexity to the telecommunications system proposed for this solicitation. Include specific experience in installing and testing telecommunications outside plant systems, including broadband cabling, and provide the names and locations of at least two project installations successfully completed using[optical fiber and] copper telecommunications cabling systems. All of the existing telecommunications system installations offered by the key persons as successful experience shall have been in successful full-time service for at least 18 months prior to the issuance date for this solicitation. Provide the name and role of the key person, the title, location, and completed installation date of the referenced project, the referenced project owner point of contact information including name, organization, title, and telephone number, and generally, the referenced project description including system size and construction complexity.

Indicate that all key persons are currently employed by the telecommunications contractor, or have a commitment to the telecommunications contractor to work on this project. All key persons shall be employed by the telecommunications contractor at the date of issuance of this solicitation, or if not, have a commitment to the telecommunications contractor to work on this project by the date that the bid was due to the Contracting Officer.

Note that only the key personnel approved by the Contracting Officer in the successful proposal shall do work on this solicitation's telecommunications system. Key personnel shall function in the same roles in this contract, as they functioned in the offered successful experience. Any substitutions for the telecommunications contractor's key personnel requires approval from The Contracting Officer.

1.6.2.3 Minimum Manufacturer's Qualifications

Cabling, equipment and hardware manufacturers shall have a minimum of 3 years experience in the manufacturing, assembly, and factory testing of components which comply with, TIA/EIA-568-B.1, TIA/EIA-568-B.2 and TIA/EIA-568-B.3. In addition, cabling manufacturers shall have a minimum of 3 years experience in the manufacturing and factory testing of cabling which comply with ICEA S-87-640, ICEA S-98-688, and ICEA S-99-689.

1.6.3 Outside Plant Test Plan

Prepare and provide a complete and detailed test plan for field tests of the outside plant including a complete list of test equipment for the copper conductor and optical fiber cables, components, and accessories for approval by the Contracting Officer. Submit the plan at least 30 days prior to tests for Contracting Officer approval. Provide outside plant testing and performance measurement criteria in accordance with TIA/EIA-568-B.1. Include procedures for certification, validation, and testing that includes fiber optic link performance criteria.

1.6.4 Standard Products

Provide materials and equipment that are standard products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and shall be the manufacturer's latest standard design that has been in satisfactory commercial or industrial use for at least 2 year prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Products supplied shall be specifically designed and manufactured for use with outside plant telecommunications systems. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.6.4.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is provided.

1.6.4.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.6.5 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.7 DELIVERY, STORAGE, AND HANDLING

Ship cable on reels in 1000 feet length with a minimum overage of 10 percent. Radius of the reel drum shall not be smaller than the minimum bend radius of the cable. Wind cable on the reel so that unwinding can be done without kinking the cable. Two meters of cable at both ends of the cable shall be accessible for testing. Attach permanent label on each reel showing length, cable identification number, cable size, cable type, and date of manufacture. Provide water resistant label and the indelible writing on the labels. Apply end seals to each end of the cables to prevent moisture from entering the cable. Reels with cable shall be suitable for outside storage conditions when temperature ranges from minus 40 degrees C to plus 65 degrees C, with relative humidity from 0 to 100 percent. Equipment, other than cable, delivered and placed in storage shall be stored with protection from weather, humidity and temperature variation, dirt and dust, or other contaminants in accordance with manufacturer's requirements.

1.8 MAINTENANCE

1.8.1 Record Documentation

Provide the activity responsible for telecommunications system maintenance and administration a single complete and accurate set of record documentation for the entire telecommunications system with respect to this project.

Provide T5 drawings including documentation on cables and termination hardware in accordance with TIA/EIA-606-A. T5 drawings shall include schedules to show information for cut-overs and cable plant management, patch panel layouts, cross-connect information and connecting terminal layout as a minimum. T5 drawings shall be provided in hard copy format on electronic media using Windows based computer cable management software. A licensed copy of the cable management software including documentation, shall be provided. Update existing record documentation to reflect campus distribution T0 drawings and T3 drawing schedule information modified, deleted or added as a result of this installation. Provide the following T5 drawing documentation as a minimum:

a. Cables - A record of installed cable shall be provided in accordance with TIA/EIA-606-A. The cable records shall [include only the required data fields include the required data fields for each cable and complete end-to-end circuit report for each

complete circuit from the assigned outlet to the entry facility

]in accordance with TIA/EIA-606-A. Include manufacture date of cable with submittal.

b. Termination Hardware - Provide a record of installed patch panels, cross-connect points, campus distributor and terminating block arrangements and type in accordance with TIA/EIA-606-A. Documentation shall include the required data fields as a minimum in accordance with TIA/EIA-606-A.

Provide record documentation as specified in Section 16710 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

1.8.2 Spare Parts

In addition to the requirements of Section 01781 OPERATION AND MAINTENANCE DATA, provide a complete list of parts and supplies, with current unit prices and source of supply, and a list of spare parts recommended for stocking. Spare parts shall be provided no later than the start of field testing.

1.9 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Products supplied shall be specifically designed and manufactured for use with outside plant telecommunications systems.

2.2 TELECOMMUNICATIONS ENTRANCE FACILITY

2.2.1 Building Protector Assemblies

Provide self-contained 5 pin unit supplied with a field cable stub factory connected to protector socket blocks to terminate and accept protector modules for 100 pairs of outside cable. Building protector assembly shall have interconnecting hardware for connection to interior cabling at full capacity. Provide manufacturers instructions for building protector assembly installation. Provide copper cable interconnecting hardware as specified in Section 16710 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

2.2.2 Protector Modules

Provide in accordance with UL 497 two-electrode gas tube or solid state type 5 pin rated for the application. Provide gas tube protection modules in accordance with RUS Bull 345-83 and shall be heavy duty, A>10kA, B>400, C>65A where A is the maximum single impulse discharge current, B is the impulse life and C is the AC discharge current in accordance with NEMA C62.61. The gas modules shall shunt high voltage to ground, fail short, and be equipped with an external spark gap and heat coils in accordance with UL 497. Provide the number of surge protection modules equal to the number of pairs of exterior cable of the building protector assembly.

2.2.3 Fiber Optic Terminations

Provide fiber optic cable terminations as specified in Section 16710 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

2.3 CLOSURES

2.3.1 Copper Conductor Closures

2.3.1.1 Underground Cable Closures

a. In vault or manhole: Provide underground closure suitable to house a straight, butt, and branch splice in a protective housing into which can be poured an encapsulating compound. Closure shall be of suitable thermoplastic, thermoset, or stainless steel material supplying structural strength necessary to pass the mechanical and electrical requirements in a vault or manhole environment. Encapsulating compound shall be reenterable and shall not alter the chemical stability of the closure. Provide filled splice cases in accordance with RUS Bull 345-72.

2.3.2 Fiber Optic Closures

2.3.2.1 In Vault or Manhole

Provide underground closure suitable to house splice organizer in a protective housing into which can be poured an encapsulating compound. Closure shall be of thermoplastic, thermoset, or stainless steel material supplying structural strength necessary to pass the mechanical and electrical requirements in a vault or manhole environment. Encapsulating compound shall be reenterable and shall not alter the chemical stability of the closure.

2.4 CABLE SPLICES, AND CONNECTORS

2.4.1 Copper Cable Splices

Provide multipair, foldback splices of a moisture resistant, two-wire insulation displacement connector held rigidly in place to assure maximum continuity in accordance with RUS Bull 1753F-401. Cables greater than 25 pairs shall be spliced using multipair splicing connectors, which accommodate 25 pairs of conductors at a time. Provide correct connector size to accommodate the cable gauge of the supplied cable.

2.4.2 Copper Cable Splice Connector

Provide splice connectors with a polycarbonate body and cap and a tin-plated brass contact element. Connector shall accommodate 22 to 26 AWG solid wire with a maximum insulation diameter of 0.065 inch. Fill connector with sealant grease to make a moisture resistant connection, in accordance with RUS Bull 1753F-401.

2.4.3 Fiber Optic Cable Splices

Provide fiber optic cable splices and splicing materials for fusionmechanical methods at locations shown on the construction drawings. The splice insertion loss shall be 0.3 dB maximum when measured in accordance with TIA-455-78-B using an Optical Time Domain Reflectometer

(OTDR). Splices shall be designed for a return loss of 40.0 db max for single mode fiber when tested in accordance with TIA-455-107A. Physically protect each fiber optic splice by a splice kit specially designed for the splice.

2.4.4 Fiber Optic Splice Organizer

Provide splice organizer suitable for housing fiber optic splices in a neat and orderly fashion. Splice organizer shall allow for a minimum of 3 feet of fiber for each fiber within the cable to be neatly stored without kinks or twists. Splice organizer shall accommodate individual strain relief for each splice and allow for future maintenance or modification, without damage to the cable or splices. Provide splice organizer hardware, such as splice trays, protective glass shelves, and shield bond connectors in a splice organizer kit.

2.4.5 Shield Connectors

Provide connectors with a stable, low-impedance electrical connection between the cable shield and the bonding conductor in accordance with RUS Bull 345-65.

2.5 CONDUIT

Provide conduit as specified in Section 16302 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND.

2.6 PLASTIC INSULATING TAPE

UL 510.

2.7 WIRE AND CABLE

2.7.1 Copper Conductor Cable

Solid copper conductors, covered with an extruded solid insulating compound. Insulated conductors shall be twisted into pairs which are then stranded or oscillated to form a cylindrical core. For special high frequency applications, the cable core shall be separated into compartments. Cable shall be completed by the application of a suitable core wrapping material, a corrugated copper or plastic coated aluminum shield, and an overall extruded jacket. Telecommunications contractor shall verify distances between splice points prior to ordering cable in specific cut lengths. Gauge of conductor shall determine the range of numbers of pairs specified; 19 gauge (6 to 400 pairs), 22 gauge (6 to 1200 pairs), 24 gauge (6 to 2100 pairs), and 26 gauge (6 to 3000 pairs). Copper conductor shall conform to the following:

2.7.1.1 Underground

Provide filled cable meeting the requirements of ICEA S-99-689 and RUS 1755.390.

2.7.1.2 Screen

Provide screen-compartmental core cable filled cable meeting the requirements of ICEA S-99-689 and RUS 1755.390.

2.7.2 Fiber Optic Cable

Provide single-mode, 8/125-um, 0.10 aperture 1550 nm fiber optic cable in accordance with TIA-492E000. Provide optical fibers as indicated. Fiber optic cable shall be specifically designed for outside use with loose buffer construction. Provide fiber optic color code in accordance with TIA/EIA-598-B

2.7.2.1 Strength Members

Provide central non-metallic strength members with sufficient tensile strength for installation and residual rated loads to meet the applicable performance requirements in accordance with ICEA S-87-640. The strength member is included to serve as a cable core foundation to reduce strain on the fibers, and shall not serve as a pulling strength member.

2.7.2.2 Shielding or Other Metallic Covering

Provide copper, copper alloy or copper and steel laminate, single tape covering or shield in accordance with ICEA S-87-640.

2.7.2.3 Performance Requirements

Provide fiber optic cable with optical and mechanical performance requirements in accordance with ICEA S-87-640.

2.7.3 Grounding and Bonding Conductors

Provide grounding and bonding conductors in accordance with RUS 1755.200, TIA J-STD-607-A, IEEE C2, and NFPA 70. Solid bare copper wire meeting the requirements of ASTM B 1 for sizes No. 8 AWG and smaller and stranded bare copper wire meeting the requirements of ASTM B 8, for sizes No. 6 AWG and larger. Insulated conductors shall have 600-volt, Type TW insulation meeting the requirements of UL 83.

2.8 T-SPAN LINE TREATMENT REPEATERS

Provide as indicated. Repeaters shall be pedestal mounted with non-pressurized housings, sized as indicated and shall meet the requirements of RUS Bull 345-50.

2.9 POLES AND HARDWARE

Provide poles and hardware as specified in Section 33 71 01, OVERHEAD TRANSMISSION AND DISTRIBUTION.

2.10 CABLE TAGS IN MANHOLES, HANDHOLES, AND VAULTS

Provide tags for each telecommunications cable or wire located in manholes, handholes, and vaults. Cable tags shall be stainless steel or polyethylene and labeled in accordance with TIA/EIA-606-A. Handwritten labeling is unacceptable.

2.10.1 Stainless Steel

Provide stainless steel, cable tags 1 5/8 inches in diameter 1/16 inch thick minimum, and circular in shape. Tags shall be die stamped with numbers, letters, and symbols not less than 0.25 inch high and approximately 0.015 inch deep in normal block style.

2.10.2 Polyethylene Cable Tags

Provide tags of polyethylene that have an average tensile strength of 3250 pounds per square inch; and that are 0.08 inch thick (minimum), non-corrosive non-conductive; resistive to acids, alkalis, organic solvents, and salt water; and distortion resistant to 170 degrees F. Provide 0.05 inch (minimum) thick black polyethylene tag holder. Provide a one-piece nylon, self-locking tie at each end of the cable tag. Ties shall have a minimum loop tensile strength of 175 pounds. The cable tags shall have black block letters, numbers, and symbols one inch high on a yellow background. Letters, numbers, and symbols shall not fall off or change positions regardless of the cable tags' orientation.

2.11 BURIED WARNING AND IDENTIFICATION TAPE

Provide fiber optic media marking and protection in accordance with TIA-590-A. Provide color, type and depth of tape as specified in paragraph BURIED WARNING AND IDENTIFICATION TAPE in Section 02300 EARTHWORK.

2.12 GROUNDING BRAID

Provide grounding braid that provides low electrical impedance connections for dependable shield bonding in accordance with RUS 1755.200. Braid shall be made from flat tin-plated copper.

2.13 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.14 FIELD FABRICATED NAMEPLATES

Provide laminated plastic nameplates in accordance with ASTM D 709 for each patch panel, protector assembly, rack, cabinet and other equipment or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 0.125 inch thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be one by 2.5 inches. Lettering shall be a minimum of 0.25 inch high normal block style.

2.15 TESTS, INSPECTIONS, AND VERIFICATIONS

2.15.1 Factory Reel Test Data

Test 100 percent OTDR test of FO media at the factory in accordance with TIA/EIA-568-B.1 and TIA/EIA-568-B.3. Use TIA-526-7 for single mode fiber and TIA-526-14-A Method B for multi mode fiber measurements. Calibrate OTDR to show anomalies of 0.2 dB minimum. Enhanced performance filled OSP copper cables, referred to as Broadband Outside Plant (BBOSP), shall meet the requirements of ICEA S-99-689. Enhanced performance air core OSP copper cables shall meet the requirements of ICEA S-98-688. Submit test reports, including manufacture date for each cable reel and receive approval before delivery of cable to the project site.

PART 3 EXECUTION

3.1 INSTALLATION

Install all system components and appurtenances in accordance with manufacturer's instructions IEEE C2, NFPA 70, and as indicated. Provide all necessary interconnections, services, and adjustments required for a complete and operable telecommunications system.

3.1.1 Contractor Damage

Promptly repair indicated utility lines or systems damaged during site preparation and construction. Damages to lines or systems not indicated, which are caused by Contractor operations, shall be treated as "Changes" under the terms of the Contract Clauses. When Contractor is advised in writing of the location of a nonindicated line or system, such notice shall provide that portion of the line or system with "indicated" status in determining liability for damages. In every event, immediately notify the Contracting Officer of damage.

3.1.2 Cable Inspection and Repair

Handle cable and wire provided in the construction of this project with care. Inspect cable reels for cuts, nicks or other damage. Damaged cable shall be replaced or repaired to the satisfaction of the Contracting Officer. Reel wraps shall remain intact on the reel until the cable is ready for placement.

3.1.3 Direct Burial System

Installation shall be in accordance with RUS Bull 1751F-640. Under railroad tracks, paved areas, and roadways install cable in conduit encased in concrete. Slope ducts to drain. Excavate trenches by hand or mechanical trenching equipment. Provide a minimum cable cover of 24 inches below finished grade. Trenches shall be not less than 6 inches wide and in straight lines between cable markers. Do not use cable plows. Bends in trenches shall have a radius of not less than 36 inches. Where two or more cables are laid parallel in the same trench, space laterally at least 3 inches apart. When rock is encountered, remove it to a depth of at least 3 inches below the cable and fill the space with sand or clean earth free from particles larger than 1/4 inch. Do not unreel and pull cables into the trench from one end. Cable may be unreeled on grade and lifted into position. Provide color, type and depth of warning tape as specified in paragraph BURIED WARNING AND IDENTIFICATION TAPE in Section 02300 EARTHWORK.

3.1.3.1 Cable Placement

a. Separate cables crossing other cables or metal piping from the other cables or pipe by not less than 3 inches of well tamped earth. Do not install circuits for communications under or above traffic signal loops.

b. Cables shall be in one piece without splices between connections except where the distance exceeds the lengths in which the cable is furnished.

c. Avoid bends in cables of small radii and twists that might cause damage. Do not bend cable and wire in a radius less than 10 times the outside diameter of the cable or wire.

d. Leave a horizontal slack of approximately 3 feet in the ground on each end of cable runs, on each side of connection boxes, and at points where connections are brought aboveground. Where cable is brought aboveground, leave additional slack to make necessary connections.

3.1.3.2 Identification Markers

Provide a marker at each change of direction of the cable, over the ends of ducts or conduits which are installed under paved areas and roadways and over each splice. Identification markers shall be of concrete, approximately 20 inches square by 6 inches thick.

3.1.3.3 Backfill for Rocky Soil

When placing cable in a trench in rocky soil, the cable shall be cushioned by a fill of sand or selected soil at least 2 inches thick on the floor of the trench before placing the cable or wire. The backfill for at least 4 inches above the wire or cable shall be free from stones, rocks, or other hard or sharp materials which might damage the cable or wire. If the buried cable is placed less than 24 inches in depth, a protective cover of concrete shall be used.

3.1.4 Cable Protection

Provide direct burial cable protection in accordance with NFPA 70 and as specified in Section 16302 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND. Galvanized conduits which penetrate concrete (slabs, pavement, and walls) shall be PVC coated and shall extend from the first coupling or fitting outside either side of the concrete minimum of 6 inches per 12 inches burial depth beyond the edge of the surface where cable protection is required; all conduits shall be sealed on each end. Where additional protection is required, cable may be placed in galvanized iron pipe (GIP) sized on a maximum fill of 40% of cross-sectional area, or in concrete encased 4 inches PVC pipe. Conduit may be installed by jacking or trenching. Trenches shall be backfilled with earth and mechanically tamped at 6 inches lift so that the earth is restored to the same density, grade and vegetation as adjacent undisturbed material.

3.1.4.1 Cable End Caps

Cable ends shall be sealed at all times with coated heat shrinkable end caps. Cables ends shall be sealed when the cable is delivered to the job site, while the cable is stored and during installation of the cable. The caps shall remain in place until the cable is spliced or terminated. Sealing compounds and tape are not acceptable substitutes for heat shrinkable end caps. Cable which is not sealed in the specified manner at all times will be rejected.

3.1.5 Underground Duct

Provide underground duct and connections to existing[manholes,][handholes,][concrete pads,][and][existing ducts] as specified in Section 16302 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND] with any additional requirements as specified herein.

3.1.6 Reconditioning of Surfaces

Provide reconditioning of surfaces as specified in Section 16302 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND.

3.1.7 Penetrations

Caulk and seal cable access penetrations in walls, ceilings and other parts of the building. Seal openings around electrical penetrations through fire resistance-rated wall, partitions, floors, or ceilings in accordance with Section 07840 FIRESTOPPING.

3.1.8 Cable Pulling

Test duct lines with a mandrel and swab out to remove foreign material before the pulling of cables. Avoid damage to cables in setting up pulling apparatus or in placing tools or hardware. Do not step on cables when entering or leaving the manhole. Do not place cables in ducts other than those shown without prior written approval of the Contracting Officer. Roll cable reels in the direction indicated by the arrows painted on the reel flanges. Set up cable reels on the same side of the manhole as the conduit section in which the cable is to be placed. Level the reel and bring into proper alignment with the conduit section so that the cable pays off from the top of the reel in a long smooth bend into the duct without twisting. Under no circumstances shall the cable be paid off from the bottom of a reel. Check the equipment set up prior to beginning the cable pulling to avoid an interruption once pulling has started. Use a cable feeder guide of suitable dimensions between cable reel and face of duct to protect cable and guide cable into the duct as it is paid off the reel. As cable is paid off the reel, lubricate and inspect cable for sheath defects. When defects are noticed, stop pulling operations and notify the Contracting Officer to determine required corrective action. Cable pulling shall also be stopped when reel binds or does not pay off freely. Rectify cause of binding before resuming pulling operations. Provide cable lubricants recommended by the cable manufacturer. Avoid bends in cables of small radii and twists that might cause damage. Do not bend cable and wire in a radius less than 10 times the outside diameter of the cable or wire.

3.1.8.1 Cable Tensions

Obtain from the cable manufacturer and provide to the Contracting Officer, the maximum allowable pulling tension. This tension shall not be exceeded.

3.1.8.2 Pulling Eyes

Equip cables 1.25 inches in diameter and larger with cable manufacturer's factory installed pulling-in eyes. Provide cables with diameter smaller than 1.25 inches with heat shrinkable type end caps or seals on cable ends when using cable pulling grips. Rings to prevent grip from slipping shall not be beaten into the cable sheath. Use a swivel of 3/4 inch links between pulling-in eyes or grips and pulling strand.

3.1.8.3 Installation of Cables in Manholes, Handholes, and Vaults

Do not install cables utilizing the shortest route, but route along those walls providing the longest route and the maximum spare cable lengths. Form cables to closely parallel walls, not to interfere with duct entrances, and support cables on brackets and cable insulators at a maximum of 4 feet. Properly arrange and supportcables. Identify each cable with

corrosion-resistant embossed metal tags.

3.1.9 Cable Splicing

3.1.9.1 Copper Conductor Splices

Perform splicing in accordance with requirements of RUS Bull 1753F-401 except that direct buried splices and twisted and soldered splices are not allowed. Exception does not apply for pairs assigned for carrier application.

3.1.9.2 Fiber Optic Splices

Fiber optic splicing shall be in accordance with manufacturer's recommendation and shall exhibit an insertion loss not greater than 0.2 dB for fusion splices.

3.1.10 Surge Protection

All cables and conductors, except fiber optic cable, which serve as communication lines through off-premise lines, shall have surge protection installed at each end which meet the requirements of RUS Bull 1751F-815.

3.1.11 Grounding

Provide grounding and bonding in accordance with RUS 1755.200, TIA J-STD-607-A, IEEE C2, and NFPA 70. Ground exposed noncurrent carrying metallic parts of telephone equipment, cable sheaths, cable splices, and terminals.

3.1.11.1 Telecommunications Master Ground Bar (TMGB)

The TMGB is the hub of the basic telecommunications grounding system providing a common point of connection for ground from outside cable, CD, and equipment. Establish a TMGB for connection point for cable stub shields to connector blocks and CD protector assemblies as specified in Section 16402 INTERIOR DISTRIBUTION SYSTEMS.

3.1.11.2 Incoming Cable Shields

Shields shall not be bonded across the splice to the cable stubs. Ground shields of incoming cables in the EF Telecommunications to the TMGB.

3.1.11.3 Campus Distributor Grounding

a. Protection assemblies: Mount CD protector assemblies directly in the telecommunications rack. Connect assemblies mounted on each vertical frame with No. 6 AWG copper conductor to provide a low resistance path to TMGB.

b. TMGB connection: Connect TMGB to TGB with copper conductor with a total resistance of less than 0.01 ohms.

]3.2 LABELING

3.2.1 Labels

Provide labeling for new cabling and termination hardware located within

the facility in accordance with TIA/EIA-606-A. Handwritten labeling is unacceptable. Stenciled lettering for cable and termination hardware shall be provided using thermal ink transfer process.

3.2.2 Cable Tag Installation

Install cable tags for each telecommunications cable or wire located in manholes, handholes, and vaults including each splice. Tag new wire and cable provided under this contract and existing wire and cable which are indicated to have splices and terminations provided by this contract. The labeling of telecommunications cable tag identifiers shall be as indicated. Tag legend shall be as indicated.] Do not provide handwritten letters. Install cable tags so that they are clearly visible without disturbing any cabling or wiring in the manholes, handholes, and vaults.

3.2.3 Termination Hardware

Label patch panels, distribution panels, connector blocks and protection modules using color coded labels with identifiers in accordance with TIA/EIA-606-A.

3.3 FIELD QUALITY CONTROL

Provide the Contracting Officer 10 working days notice prior to each test. Provide labor, equipment, and incidentals required for testing. Correct defective material and workmanship disclosed as the results of the tests. Furnish a signed copy of the test results to the Contracting Officer within 3 working days after the tests for each segment of construction are completed. Perform testing as construction progresses and do not wait until all construction is complete before starting field tests.

3.3.1 Pre-Installation Tests

Perform the following tests on cable at the job site before it is removed from the cable reel. For cables with factory installed pulling eyes, these tests shall be performed at the factory and certified test results shall accompany the cable.

3.3.1.1 Cable Capacitance

Perform capacitance tests on at least 10 percent of the pairs within a cable to determine if cable capacitance is within the limits specified.

3.3.1.2 Loop Resistance

Perform DC-loop resistance on at least 10 percent of the pairs within a cable to determine if DC-loop resistance is within the manufacturer's calculated resistance.

3.5.1.3 Pre-Installation Test Results

Provide results of pre-installation tests to the Contracting Officer at least 5 working days before installation is to start. Results shall indicate reel number of the cable, manufacturer, size of cable, pairs tested, and recorded readings. When pre-installation tests indicate that cable does not meet specifications, remove cable from the job site.

3.3.2 Acceptance Tests

Perform acceptance testing in accordance with RUS Bull 1753F-201 and as further specified in this section. Provide personnel, equipment, instrumentation, and supplies necessary to perform required testing. Notification of any planned testing shall be given to the Contracting Officer at least 14 days prior to any test unless specified otherwise. Testing shall not proceed until after the Contractor has received written Contracting Officer's approval of the test plans as specified. Test plans shall define the tests required to ensure that the system meets technical, operational, and performance specifications. The test plans shall define milestones for the tests, equipment, personnel, facilities, and supplies required. The test plans shall identify the capabilities and functions to be tested. Provide test reports in booklet form showing all field tests performed, upon completion and testing of the installed system.

Measurements shall be tabulated on a pair by pair or strand by strand basis.

3.3.2.1 Copper Conductor Cable

Perform the following acceptance tests in accordance with TIA-758-A:

a. Wire map (pin to pin continuity)
b. Continuity to remote end
c. Crossed pairs
d. Reversed pairs
e. Split pairs
f. Shorts between two or more conductors

3.3.2.2 Fiber Optic Cable

Test fiber optic cable in accordance with TIA/EIA-455-B and as further specified in this section. Two optical tests shall be performed on all optical fibers: Optical Time Domain Reflectometry (OTDR) Test, and Attenuation Test.

a. OTDR Test: The OTDR test shall be used to determine the adequacy of the cable installations by showing any irregularities, such as discontinuities, micro-bendings or improper splices for the cable span under test. Hard copy fiber signature records shall be obtained from the OTDR for each fiber in each span and shall be included in the test results. The OTDR test shall be measured in both directions. A reference length of fiber, 66 feet minimum, used as the delay line shall be placed before the new end connector and after the far end patch panel connectors for inspection of connector signature. Conduct OTDR test and provide calculation or interpretation of results in accordance with TIA-526-7 for single-mode fiber and TIA-526-14-A for multimode fiber. Splice losses shall not exceed 0.3 db.

b. Attenuation Test: End-to-end attenuation measurements shall be made on all fibers, in both directions, using a[850][1300][1310][1550] nanometer light source at one end and the optical power meter on the other end to verify that the cable system

attenuation requirements are met in accordance with[TIA-455-46A for multimode][and][TIA-526-7 for single-mode] fiber optic cables. The measurement method shall be in accordance with TIA-455-78-B. Attenuation losses shall not exceed 0.5 db/km at 1310 nm and 1550 nm for single-mode fiber. Attenuation losses shall not exceed 5.0 db/km at 850 nm and 1.5 db/km at 1300 nm for multimode fiber.

-- End of Section --