1. Specification 024116 – Structure Demolition
2. Specifications 260010 - Supplemental Requirements for Electrical
3. Specifications 260011 – Facility Performance Requirements for Electrical
4. Specifications 260513 – Medium-Voltage Cables
5. Specifications 260526 – Grounding and Bonding for Electrical Systems
6. Specifications 260573 – Power System Studies
7. Specifications 261326 – Medium-Voltage Metal-Clad Switchgear

SECTION 024116 - STRUCTURE DEMOLITION

PART 1 - GENERAL

1.1 SUMMARY

A. The Work of this Section Includes:

1. Demolition and removal of existing 5KV Switchgear, components, and all materials associated with the work no longer required for the new infrastructure.
2. Demolition and removal of site improvements.
3. Removing below-grade construction.
4. Disconnecting, capping or sealing, and abandoning in-place site utilities.
5. Disconnecting, capping or sealing, and removing site utilities.

1.2 MATERIALS OWNERSHIP

A. Unless otherwise indicated, demolition waste becomes property of Contractor.

1.3 COORDINATION

A. Arrange demolition schedule so as not to interfere with Forest Service on-site operations.

1.4 PREINSTALLATION MEETINGS

A. Pre-demolition Conference: Conduct conference at Project site.

1.5 INFORMATIONAL SUBMITTALS

A. Survey of Existing Conditions: Submit survey.

B. Proposed Protection Measures: Submit report, including Drawings, that indicates the measures proposed for protecting individuals and property for environmental protection, for dust control and, for noise control. Indicate proposed locations and construction of barriers.

C. Schedule of building demolition activities with starting and ending dates for each activity.

1.6 CLOSEOUT SUBMITTALS

A. Inventory: Submit a list of items that have been removed and salvaged.

1.7 FIELD CONDITIONS

A. Hazardous Materials:

a. Hazardous materials will be removed by Contractor before start of the Work.
b. It was observed that asbestos is present in some MV cables insulation. If materials suspected of containing hazardous materials are encountered, do not disturb; immediately notify the Forest Service. Hazardous materials will be removed by the Contractor before the start of work.

B. On-site sale of removed items or materials is not permitted.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Comply with governing EPA notification regulations before beginning demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.

B. Standards: Comply with ANSI/ASSP A10.6 and NFPA 241.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that utilities have been disconnected and capped before starting demolition operations.

B. Existing Utilities to Remain: Maintain utility services to remain and protect against damage during demolition operations.

1. Do not interrupt existing utilities serving adjacent occupied or operating facilities unless authorized in writing by Owner and authorities having jurisdiction.

2. Provide at least 72 hours' notice to occupants of affected buildings if shutdown of service is required.

C. Existing Utilities to Be Disconnected: Locate, identify, disconnect, and seal or cap off utilities serving buildings and structures to be demolished.

1. Owner will arrange to shut off utilities when requested by Contractor.
2. If disconnection of utility services will affect adjacent occupied buildings, then provide temporary utilities that bypass buildings and structures to be demolished and that maintain continuity of service to other buildings and structures.
3. Cut off pipe or conduit a minimum of 24 inches (610 mm) below grade at or outside the building or structure to be demolished and cap, valve, or plug and seal remaining portion of pipe or conduit in accordance with requirements of authorities having jurisdiction.
4. Do not start demolition work until utility disconnecting and sealing have been completed and verified in writing by authorities having jurisdiction.

3.2 DEMOLITION, GENERAL

A. General: Demolish indicated outdoor switchgear completely. Use methods required to complete the Work within limitations of governing regulations and as follows:

1. Do not use cutting torches until work area is cleared of flammable materials. Maintain portable fire-suppression devices during flame-cutting operations.
2. Maintain fire watch during and for at least 12 hours after flame-cutting operations.
3. Maintain adequate ventilation when using cutting torches.
4. Locate building demolition equipment as directed by the Forest Service and remove debris and materials from the site daily.

B. Site Access and Temporary Controls: Conduct building demolition and debris-removal operations to ensure minimum interference with roads, streets, walkways, parking spaces and other adjacent occupied and used facilities.

1. Do not close or obstruct streets, walks, walkways, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed trafficways if required by authorities having jurisdiction.
2. Use water mist and other suitable methods to limit spread of dust and dirt. Comply with governing environmental-protection regulations. Do not use water when it may damage adjacent construction or create hazardous or objectionable conditions.

C. Explosives: Use of explosives is not permitted.

3.3 SITE RESTORATION

A. Below-Grade Areas:

1. Rough grade below-grade areas ready for further excavation or new construction.
2. Completely fill below-grade areas and voids resulting from building demolition operations with satisfactory soil materials or recycled pulverized concrete.

B. Site Grading: Uniformly rough grade area of demolished construction to a smooth surface, free from irregular surface changes. Provide a smooth transition between adjacent existing grades and new grades.

3.4 REPAIRS

A. Promptly repair damage to adjacent buildings caused by demolition operations.

3.5 DISPOSAL OF DEMOLISHED MATERIALS

A. Remove demolition of waste materials from the project site and dispose of them in an EPA-approved construction and demolition waste landfill acceptable to authorities having jurisdiction.

1. Do not allow demolished materials to accumulate on-site.

2. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.

B. Do not burn demolished materials.

3.6 CLEANING

A. Clean adjacent structures and improvements of dust, dirt, and debris caused by building demolition operations. Return adjacent areas to condition existing before building demolition operations began.

END OF SECTION 024116

SECTION 260010 - SUPPLEMENTAL REQUIREMENTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Requirements generally applicable to all electrical Work on the Project, including but not limited to Work specified in Divisions 26

1.2 COORDINATION

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions:

1. Notify the COR, local POC and tenants no fewer than 72 hours in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without written permission.
3. Coordinate interruption with systems impacted by outage including, but not limited to, the following:

a. Exercising generators.
b. Emergency lighting.
c. Elevators.
d. Fire alarm systems.
e. Server Room

4. Facility will remain occupied during the outage. Plan and coordinate power requirements, interruptions, and reconfiguring the existing emergency generator (Prime and Standby) feeders to the building to maintain power during construction.

1.3 PREINSTALLATION MEETINGS

A. Electrical Preconstruction Conference: Schedule conference with the Owner, not later than [**10**] days after Notice to Proceed. Agenda topics include, but are not limited to, the following:

1. Electrical installation schedule.
2. Status of power system studies.
3. Utility work coordination and class of service requests.
4. Commissioning activities.

1.4 SEQUENCING

A. Conduct and submit results of power system studies before submitting product data and shop drawings for electrical equipment as specified in Specifications 260573 Power System Studies.

1.5 ACTION SUBMITTALS

A. Coordination Drawings for Structural Supports: Show coordination of structural supports for equipment and devices, including restraints and bracing for control of seismic and wind loads, with other systems, equipment, and structural supports in the vicinity.

1.6 INFORMATIONAL SUBMITTALS

A. Electrical Installation Schedule: At preconstruction meeting, and periodically thereafter as dates change, provide schedule for electrical installation Work to Owner, but not limited to, milestone dates for the following activities:

1. Submission of power system studies.
2. Submission of specified coordination drawings.
3. Submission of action submittals specified in Division 26.
4. Orders placed for major electrical equipment.
5. Arrival of major electrical equipment on-site.
6. Preinstallation meetings specified in Division 26.
7. Utility service outages.
8. Utility service inspection and activation.
9. Mockup reviews.
10. System startup, testing, and commissioning activities for major electrical equipment.
11. Pouring concrete housekeeping pads for electrical equipment and testing concrete samples (as required).
12. Requests for inspections by authorities having jurisdiction.

B. Qualification Statements:
1. For professional structural engineer.
2. For professional electrical engineer.
3. For medium-voltage cable Installer.
4. For medium-voltage duct Installer.
5. For medium-voltage equipment Installer.
6. For medium-voltage electrical testing agency and on-site electrical testing supervisor.
7. For power-limited electrical testing agency and on-site power-limited testing supervisor.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:

1. Provide emergency operation, normal operation, and preventive maintenance manuals for each system, equipment, and device listed below:

a. Outdoor Metal Clad Switchgear

2. Include the following information:

   a. Manufacturer's operating specifications.
   b. User's guides for software and hardware.
   c. Schedule of maintenance material items recommended to be stored at Project site.
   d. Detailed instructions covering operation under both normal and abnormal conditions.
   e. Time-current curves for overcurrent protective devices and manufacturer's written instructions for testing and adjusting their settings.
   f. List of load-current and overload-relay heaters with related motor nameplate data.
   g. List of lamp types and photoelectric relays used on the Project, with ANSI and manufacturers' codes.
   h. Manufacturer's instructions for setting field-adjustable components.
   i. Manufacturer's instructions for testing, adjusting, and reprogramming microprocessor controls.
   j. EPSS: Manufacturer's system checklists, maintenance schedule, and maintenance log sheets in accordance with NFPA 110.
   k. Exterior pole inspection and repair procedures.

PART 2 - PRODUCTS

2.1 SUBSTITUTION LIMITATIONS FOR ELECTRICAL EQUIPMENT

A. Substitution requests for electrical equipment will be entertained under the following conditions:

1. Substitution requests may be submitted for consideration prior to the Electrical Preconstruction Conference if accompanied by value analysis data indicating that substitution will comply with Project performance requirements while significantly increasing value for Owner throughout life of facility at no additional cost to the government.
2. Substitution requests may be submitted for consideration concurrently with submission of power system study reports when those reports indicate that substitution is necessary for safety of maintenance personnel and facility occupants at no additional cost to the government.
3. Contractor is responsible for sequencing and scheduling power system studies and electrical equipment procurement. After the Electrical Preconstruction Conference, insufficient lead time for electrical equipment delivery will not be considered a valid reason for substitution.

PART 3 - EXECUTION

3.1 INSTALLATION OF ELECTRICAL WORK

A. Unless more stringent requirements are specified in the Contract Documents or manufacturers' written instructions, comply with NFPA 70 and NECA NEIS 1 for installation of electrical Work on the Project.

3.2 CLEANING

A. Contractor shall be responsible for the final cleanup and disposal of all demolished materials and equipment from the site.

END OF SECTION 260010

SECTION 260011 - FACILITY PERFORMANCE REQUIREMENTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Field conditions and other facility performance requirements applicable to Work specified in Division 26.

1.2 FIELD CONDITIONS

A. Seismic Hazard Design Loads:

1. Unless otherwise indicated in Contract Documents, specified Work must withstand seismic hazard design loads determined in accordance with requirements specified in this Section, adjusted for installed elevation above or below grade.

    a. The term "withstand" means "unit must remain in place without separation of parts from unit when subjected to specified seismic hazard design load and unit must be fully operational after seismic event

2. Perform calculations to obtain force information necessary to properly select seismic-restraint devices, fasteners, and anchorage. Perform calculations using methods acceptable to applicable code authorities. Where "ASCE/SEI 7" is used throughout this Section, it must be understood that the edition referred to in this subparagraph is the edition intended as reference throughout the Section Text.

    a. Data indicated below to be determined by Delegated Design Contractor must be obtained by Contractor and must be included in individual component submittal packages.
    b. Coordinate seismic design calculations with wind-load calculations for equipment mounted outdoors.

B. Wind Hazard Design Loads:

3. Perform calculations to obtain force information necessary to properly select wind-load restraint devices, fasteners, and anchorage. Perform calculations using methods acceptable to applicable code authorities. Where "ASCE/SEI 7" is used throughout this Section, it must be understood that the edition referred to in this subparagraph is intended as referenced throughout the Section Text unless otherwise indicated.

    a. Data indicated below that are specific to individual pieces of equipment must be obtained by Contractor and must be included in individual component submittal packages.

b. Coordinate design wind-load calculations with seismic-load calculations for equipment requiring both seismic- and wind-load reinforcement. Comply with requirements in other Sections in addition to those in this Section.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 260011

SECTION 260513 - MEDIUM-VOLTAGE CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cables.
2. Connectors.
3. Solid terminations.
4. Separable insulated connectors.
5. Splice kits.
6. Medium-voltage tapes.
7. Arc-proofing materials.
8. Fault indicators.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of cable. Include splices and terminations for cables and cable accessories.

B. Samples: 16 inch (400 mm) lengths for each type of cable specified.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with IEEE C2 and NFPA 70.

C. Source Limitations: Obtain cables and accessories from single source from single manufacturer.

2.2 CABLES

A. Cable Type: (as specified by Designer and existing Utility requirements)

B. Conductor Insulation: (as specified by Designer and existing Utility requirements)

1. Voltage Rating: 5kV.
2. Insulation Thickness: 133 percent insulation level.

C. Conductor: Copper

D. Comply with UL 1072, AEIC CS8

E. Conductor Stranding: Compact round, concentric lay, Class B

F. Strand Filling: Conductor interstices are filled with impermeable compound.

G. Shielding: Copper tape**,** helically applied over semiconducting insulation shield.

H. Shielding and Jacket: Corrugated copper drain wires embedded in extruded, chlorinated, polyethylene jacket.

I. Three-Conductor Cable Assembly: Three insulated, shielded conductors cabled together with ground conductors.

J. Cable Jacket: Sunlight-resistant PVC

2.3 CONNECTORS

A. Comply with ANSI C119.4 for connectors between aluminum conductors or for connections between aluminum to copper conductors.

B. Copper-Conductor Connectors: Copper barrel crimped connectors.

2.4 SOLID TERMINATIONS

A. Multiconductor Cable Sheath Seals: Type recommended by seal manufacturer for type of cable and installation conditions, including orientation.

1. Cold-shrink sheath seal kit with preformed sleeve openings sized for cable and insulated conductors.
2. Heat-shrink sheath seal kit with phase- and ground-conductor rejacketing tubes, cable-end sealing boot, and sealing plugs for unused ground-wire openings in boot.

B. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class shall be equivalent to that of cable. Include shield ground strap for shielded cable terminations.

1. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief tube; multiple, molded-silicone-rubber, insulator modules; shield ground strap; and compression-type connector.

2.5 SEPARABLE INSULATED CONNECTORS

A. Description: Modular system with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.

B. Standard: Comply with IEEE 386.

C. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.

D. Load-Break Cable Terminators: Elbow-type units with 200 A load make/break and continuous-current rating; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

E. Dead-Break Cable Terminators: Elbow-type unit with 200 A continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test points on terminator body that is capacitance coupled.

F. Dead-Front Terminal Junctions: Modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer's standard accessory stands, stainless steel mounting brackets, and attaching hardware.

1. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.
2. Portable Feed-Through Accessory: Two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.
3. Grounding Kit: Jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders and carrying case.
4. Standoff Insulator: Portable, single dead-front terminal for removable mounting on accessory stand of stationary terminal junction. Insulators suitable for fully insulated isolation of energized cable-elbow terminator.

G. Test-Point Fault Indicators: Applicable current-trip ratings and arranged for installation in test points of load-break separable connectors, and complete with self-resetting indicators capable of being installed with shotgun hot stick and tested with test tool.

H. Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool, and carrying case.

2.6 SPLICE KITS

A. Description: For splicing medium voltage cables; type as recommended by cable or splicing kit manufacturer for the application.

B. Standard: Comply with IEEE 404.

C. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, materials, ratings, and configurations of cable conductors. Include all components required for complete splice, with detailed instructions.

2.7 MEDIUM-VOLTAGE TAPES

A. Description: Electrical grade, insulating tape for medium voltage application.

B. Ethylene/propylene rubber-based, 30 mil (0.76 mm) splicing tape, rated for 130 deg C operation. Minimum 3/4 inch (20 mm) wide.

C. Silicone rubber-based, 12 mil (0.30 mm) self-fusing tape, rated for 130 deg C operation. Minimum 1-1/2 inch (38 mm) wide.

D. Insulating-putty, 125 mil (3.175 mm) elastic filler tape. Minimum 1-1/2 inches (38 mm) wide.

2.8 ARC-PROOFING MATERIALS

A. Tape for First Course on Metal Objects: 10 mil (250 micrometer) thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.

B. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3 inch (8 mm) thick, and compatible with cable jacket.

C. Glass-Cloth Tape: Pressure-sensitive adhesive type, 1 inch (25 mm) wide.

2.9 FAULT INDICATORS

A. Indicators: Automatically reset fault indicator with inrush restraint feature, arranged to clamp to cable sheath and provide a display after a fault has occurred in cable. Instrument shall not be affected by heat, moisture, and corrosive conditions and shall be recommended by manufacturer for installation conditions.

B. Resetting Tool: Designed for use with fault indicators, with moisture-resistant storage and carrying case.

2.10 SOURCE QUALITY CONTROL

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A. Test and inspect cables according to ICEA S-97-682 before shipping.

B. Test strand-filled cables for water-penetration resistance according to ICEA T-31-610, using a test pressure of 5 psig (35 kPa).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cables according to IEEE 576.

B. Proof conduits prior to conductor installation by passing a wire brush mandrel and then a rubber duct swab through the conduit. Separate the wire brush and the rubber swab by 48 to 72 inch (1200 to 1800 mm) on the pull rope.

1. Wire Brush Mandrel: Consists of a length of brush approximately the size of the conduit inner diameter with stiff steel bristles and an eye on each end for attaching the pull ropes. If an obstruction is felt, pull the brush back and forth repeatedly to break up the obstruction.
2. Rubber Duct Swab: Consists of a series of rubber discs approximately the size of the conduit inner diameter on a length of steel cable with an eye on each end for attaching the pull ropes. Pull the rubber duct swab through the duct to extract loose debris from the duct.

C. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

1. Where necessary, use manufacturer-approved pulling compound or lubricant that does not deteriorate conductor or insulation.
2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips, that do not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.
3. Use pull-in guides, cable feeders, and draw-in protectors as required to protect cables during installation.
4. Do not pull cables with ends unsealed. Seal cable ends with rubber tape.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

E. bed of 3 inch (75 mm) thick, clean sand. Separate cables crossing other cables or piping by a minimum of 2 inch (50 mm) of tamped earth, plus an additional 2 inch (50 mm) of sand. Install permanent markers at ends of cable runs, changes in direction, and buried splices.

F. Install "buried-cable" warning tape 12 inch (305 mm) above cables.

G. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit; support cables at intervals adequate to prevent sag.

H. Install sufficient cable length to remove cable ends under pulling grips. Remove length of conductor damaged during pulling.

I. Install cable splices at pull points and elsewhere as indicated; use standard kits.

J. Install terminations at ends of conductors, and seal multiconductor cable ends with standard kits.

K. Install separable insulated-connector components as follows:

1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.
2. Portable Feed-Through Accessory: At each terminal junction, with one on each terminal.
3. Standoff Insulator: At each terminal junction, with one on each terminal.

L. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials. In addition to arc-proofing tape manufacturer's written instructions, apply arc proofing as follows:

1. Clean cable sheath.
2. Wrap metallic cable components with 10 mil (250 micrometer) pipe-wrapping tape.
3. Smooth surface contours with electrical insulation putty.
4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
5. Band arc-proofing tape with two layers of 1 inch (25 mm) wide half-lapped, adhesive, glass-cloth tape at each end of the arc-proof tape.

M. Seal around cables passing through fire-rated elements according to Section 078413 "Penetration Firestopping."

N. Install fault indicators on each phase where indicated.

O. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.

P. Ground shields of shielded cable at one point only. Maintain shield continuity and connections to metal connection hardware at all connection points.

Q. Identify cables according to Section 260553 "Identification for Electrical Systems." Identify phase and circuit number of each conductor at each splice, termination, pull point, and junction box. Arrange identification so that it is unnecessary to move the cable or conductor to read the identification.

3.2 FIELD QUALITY CONTROL

1. Electrical test stated in NETA ATS. Certify compliance with test parameters.
2. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.
3. Perform Partial Discharge test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer's recommendations.
4. Perform Dissipation Factor test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer's recommendations.

B. Prepare test and inspection reports.

END OF SECTION 260513

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Grounding and bonding conductors.
2. Grounding and bonding clamps.
3. Grounding and bonding bushings.
4. Grounding and bonding hubs.
5. Grounding and bonding connectors.
6. Intersystem bonding bridge grounding connectors.
7. Grounding and bonding busbars.
8. Signal reference grids.
9. Grounding (earthing) electrodes.
10. Grounding electrode enclosures.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.

2. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.

C. Shop Drawings: Prepare and submit the following:

1. Plans showing dimensioned locations of grounding features described in "Field Quality Control for Grounding and Bonding" Article, including the following:

   a. Grounding electrode access enclosures.
   b. Grounding electrodes.
   c. Grounding arrangements and connections for separately derived systems.

D. Field quality-control reports.

1.2 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:

1. In addition to items specified in Section 260010 "Supplemental Requirements for Electrical," include the following:

   a. Plans showing locations of grounding features described in "Field Quality Control for Grounding and Bonding" Article, including the following:

1) Grounding electrode access enclosures.
2) Grounding electrodes.
3) Grounding arrangements and connections for separately derived systems.

b. Instructions for periodic testing and inspection of grounding features at grounding connections for separately derived systems based on NFPA 70B 2023.

1) Tests must determine if ground-resistance or impedance values remain within specified maximums, and instructions must recommend corrective action if values do not.
2) Include recommended testing intervals.

1.3 QUALIFICATIONS

A. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.

1.4 SERVICE CONDITIONS FOR ELECTRICAL EQUIPMENT

A. Electrical and ICT Equipment Grounding (Earthing): Do not exceed **10 Ω** resistance to ground (earth).
1. Contact Engineer of Record for resolution if **10 Ω** specified resistance to ground (earth) is not attained after second attempt to increase effectiveness of grounding (earthing) electrode.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

2.2 GROUNDING AND BONDING CONDUCTORS

A. Equipment Grounding Conductor:

1. Standard Features: 600 V, THHN/THWN-2 or THWN-2, copper wire or cable, green color, in accordance with the NEC.

B. Isolated Equipment Grounding Conductor:

1. Standard Features: 600 V, THHN/THWN-2 or THWN-2, copper wire or cable, green with one or more yellow stripes, in accordance with the NEC.

C. ASTM - Bare Copper Grounding and Bonding Conductor:
1. Standard Features: Complying with one or more of the following:

a. Soft or Annealed Copper Wire: ASTM B3.
b. Concentric-Lay Stranded Copper Conductor: ASTM B8.
c. Tin-Coated Soft or Annealed Copper Wire: ASTM B33.
d. 19-Wire Combination Unilay-Stranded Copper Conductor: ASTM B787/B787M.

2.3 GROUNDING AND BONDING CLAMPS

A. Description: Clamps suitable for attachment of grounding and bonding conductors to grounding electrodes, pipes, tubing, and rebar. Grounding and bonding clamps specified in this article are also suitable for use with communications applications.

2.4 GROUNDING AND BONDING CONNECTORS

A. UL KDER - Pressure-Type Grounding and Bonding Busbar Cable Connector
1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guided information and standards specified for the following UL product categories:

a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.

2. Standard Features: Copper or copper alloy, for compression bonding of one or more conductors directly to copper busbar. Listed for direct burial.

a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.

3. Standard Features: Bolts that surround cable and bond to cable under compression when nut is tightened.

a. Copper

4. Standard Features: Zinc-alloy one-piece construction; six terminating points; gangable.

a. Bus: Rectangular bar of annealed copper.
b. Mounting Stand-Off Insulators: Lexan or PVC.

1) Comply with UL 891 for use in 600 V switchboards, impulse tested at 5000 V.

c.

2.5 SIGNAL REFERENCE GRIDS

A. Description: Means for providing low-impedance path to ground over a large area, approximating an equipotential plan, while simultaneously mitigating large current spikes from faults or lightning.

B. UL KDER - Mesh-Type Signal Reference Grid
   1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guided information and standards specified for the following UL product categories:

      a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

   2. Standard Features: Conductive metal wire mesh for field-fabrication of grid.

2.6 GROUNDING (EARTHING) ELECTRODES

A. UL KDER - Rod Electrode
   1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guided information and standards specified for the following UL product categories:

      a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

   2. Standard Features: Copper-clad 3/4 inch by 10 ft (19 mm by 3 m)

2.7 GROUNDING ELECTRODE ENCLOSURES

A. Description: Enclosures designed to protect grounding electrodes from damage while providing access for inspection and testing of the grounding system.

B. Grounding Electrode Access Well Enclosure
   1. Standard Features:

      a. Well Material: Concrete
      b. Cover Material Concrete
      c. Cover Strength: Sidewalk or turf use

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine facility's grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of electrical system.

B. Inspect test results of grounding system measured at point of electrical service equipment connection.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

D. Proceed with connection of electrical service equipment only after unsatisfactory conditions have been corrected.

3.2 SELECTION OF GROUNDING AND BONDING PRODUCTS

A. Grounding and Bonding Conductors:

1. Provide solid conductors for 8 AWG and smaller, and stranded conductors for 6 AWG and larger unless otherwise indicated.
2. Custom-Length Insulated Equipment Bonding Jumpers: 6 AWG, 19-strand, Type THHN.

B. Grounding and Bonding Connectors:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

C. Grounding and Bonding Busbars: Provide in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated on the Drawings.

D. Substation Signal Reference Grid:

1. Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with IEEE C2.

    a. Install 6 AWG or wire size from fault calculation bonding conductors below grade in a grid pattern on 2 ft (600 mm) centers. Bond grid conductors with exothermic welds where they cross each other.
    b. Grid must fill entire area inside equipment yard fence and extend minimum 6.5 ft (2 m) outside fence, so someone walking or running outside yard may not touch fence or open gate without first stepping inside grid.
    c. Bond each metal fence post and gate post to at least two grid conductors.
    d. Inside grid, bond equipment reinforcing steel inside bases and sidewalks to at least two grid conductors.
    e. Bond underground metal pipe and conduit passing under grid to nearest grid conductor at both ends.

3.3 INSTALLATION OF GROUNDING AND BONDING

A. Comply with manufacturer's published instructions.

B. Reference Standards:

1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
2. Electrical Maintenance: NFPA 70B.
3. Electrical Safety: NFPA 70E.
4. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
5. Emergency and Standby Power Work: NFPA 110, NFPA 111, and NECA NEIS 416.
6. Work in Confined Spaces: NFPA 350.
7. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.

8. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor and install in conduit.
9. Consult Engineer of Record for resolution of conflicting requirements.

C. Protection: After installation, protect grounding and bonding cables and equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.4 FIELD QUALITY CONTROL FOR GROUNDING AND BONDING

A. Administration for Electrical Power Tests and Inspections:

1. Owner will engage in qualified electrical testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representatives to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections with assistance of factory-authorized service representative.

B. Acceptance Testing Preparation:

C. Field tests and inspections must be witnessed by authorities having jurisdiction

D. Tests and Inspections:

1. After installing grounding system, before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with calibrated torque wrench in accordance with manufacturer's published instructions.
3. Test completed grounding system at each location where maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal**,** at ground test well, and at individual ground rods. Make tests at ground rods before conductors are connected.

    a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    b. Perform tests by fall-of-potential method in accordance with IEEE Std 81.
    c. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order and key to record tests and observations. Include number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

E. Nonconforming Work:

1. Grounding system will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective components and retest.

F. Collect, assemble, and submit test and inspection reports.

1. Report measured ground resistances that exceed the following values:

a. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 Ω
b. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 Ω
c. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 Ω
d. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 Ω
e. Substations and Pad-Mounted Equipment: 5 Ω
f. Manhole Grounds: 10 Ω

END OF SECTION 260526

SECTION 260573 - POWER SYSTEM STUDIES

PART 1 - GENERAL

1.1 SUMMARY

A. The Work of this Section Includes:

1. Short-circuit study.
2. Overcurrent protective device coordination study.
3. Load-flow and voltage-drop study.
4. Arc-flash hazard study.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For power system analysis software to be used for studies.

1. Product Certificates: For power system study software applications, including certificate stating compliance with specified requirements, signed by software manufacturer.

B. Power System Study Reports:

1. Submit reports after approval of system protective devices submittals. Submittals must be in digital form.
2. Submit short-circuit study input data, including completed computer-program input data sheets.
3. Submit coordination study input data, including completed computer-program input data sheets.

    a. Submit load-flow and voltage-drop, with coordination study.

4. Submit arc-flash study input data, including completed computer-program input data sheets.
5. Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies cause delay in equipment manufacturing, obtain approval from Engineer of Record for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.
6. Submit revised one-line diagram, reflecting field investigation results and results of short-circuit study.

C. Data files for studies in format compatible with Owner's power system analysis software.

D. Digital-twin models.

1.3 QUALITY ASSURANCE

A. Submittals for power system studies must be signed and sealed by qualified professional electrical engineer (State of California) responsible for their preparation.

B. Studies must be performed using commercially developed and distributed software designed specifically for power system analysis.

C. Software algorithms must comply with requirements of standards and guides specified in this Section.

D. Manual calculations are unacceptable.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE

A. Standard Features:

1. Power System Analysis:

   a. Power-systems-analysis software applications must have analytical capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 3002 series standards.
   b. Computer software applications must be capable of plotting and diagramming time-current-characteristic curves as part of their output. Computer software programs must report device settings and ratings of overcurrent protective devices and must demonstrate selective coordination by computer-generated, time-current coordination plots.
   c. Computer software applications must be designed to perform arc-flash analysis or have function, component, or add-on module designed to perform arc-flash analysis.

2. Analysis Standards:

   a. Short-Circuit Current Analysis: In accordance with IEEE 3002.3.
   b. Device Coordination Analysis: In accordance with IEEE 3004.3 and IEEE 3004.5.
   c. Load-Flow Analysis: In accordance with IEEE 3002.2.
   d. Motor-Starting Analysis: In accordance with IEEE 3002.7.
   e. Harmonic Analysis: In accordance with IEEE 3002.8.
   f. Transient Stability Analysis: In accordance with IEEE P3002.9.
   g. Arc-Flash Hazard Analysis: In accordance with IEEE 1584.

3. Capable of printing arc-flash hazard warnings for equipment on vinyl weather- and UV-resistant, pressure-sensitive adhesive labels complying with NFPA 70E.

a. Label must have orange header with wording, "WARNING, ARC-FLASH HAZARD," and must include the following information taken directly from arc-flash hazard study:

1) Equipment designation.
2) Nominal voltage.
3) Protection boundaries.

a) Arc-flash boundary.
b) Restricted approach boundary.
c) Limited approach boundary.

4) Arc-flash PPE category.
5) Required minimum arc rating of PPE in Cal/cm squared.
6) Available incident energy.
7) Working distance.
8) Engineering report number, revision number, and issue date.

B. Other Available Features Required by the Project:
1. Explicit negative sequence.
2. Mutual coupling in zero sequence.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Collect and analyze data for power system studies.

1. Verify completeness of data supplied in one-line diagram on Drawings. Call discrepancies for Engineer of Record attention.
2. For equipment included as Work on the Project, use characteristics submitted under provisions of action submittals and information submittals for the Project.
3. For equipment that exists to remain, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers in accordance with NFPA 70E.
4. Gather and tabulate required input data to support power system studies. Comply with requirements in Section 017839 "Project Record Documents" for recording circuit protective device characteristics. Record data on Record Document copy of one-line diagram. Comply with recommendations in IEEE 3002 series standards as to amount of detail that is required to be acquired in field. Field data gathering must be by, or under supervision of, qualified professional electrical engineers. Data includes, but are not limited to, the following:

a. Product data for the Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
b. Electrical power utility impedance at service.
c. Power sources and ties.

d. Short-circuit current at each bus system (three phase and line to ground).
e. Full-load current of loads.
f. Voltage level at each bus.
g. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
h. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
i. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
j. Generators short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
k. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
l. Maximum demands from service meters.
m. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
n. Motor horsepower and NEMA MG 1 code letter designation.
o. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
p. Medium-voltage cable sizes, lengths, conductor material, cable construction, metallic shield performance parameters, and conduit material (magnetic or nonmagnetic).
q. Derating factors.

3.2 PREPARATION

A. Preparation of Data for Short-Circuit Study:

1. Verify completeness of data supplied on one-line diagram. Call discrepancies to Architect's attention.
2. For equipment included as Work on the Project, use characteristics submitted under provisions of action submittals and information submittals for the Project.
3. Prepare one-line diagram of modeled power system, showing the following:

a. Protective device designations and ampere ratings.
b. Conductor types, sizes, and lengths.
c. Transformer kVA and voltage ratings.
d. Motor and generator designations and kVA ratings.
e. Switchgear, switchboard, motor-control center, and panelboard designations and ratings.
f. Derating factors and environmental conditions.
g. Revisions to electrical equipment required by study.

B. Preparation of Data for Overcurrent Protective Device Coordination Study:

1. Prepare data sheets to supplement electrical distribution system one-line diagram, cross-referenced with tag numbers on diagram, indicating the following:

a. Special load considerations, including starting inrush currents and frequent starting and stopping.
b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
d. Generator thermal-damage curve.
e. Ratings, types, and settings of utility company's overcurrent protective devices.
f. Special overcurrent protective device settings or types stipulated by utility company.
g. Time-current-characteristic curves of devices indicated to be coordinated.
h. Manufacturer, frame size, interrupting rating in amperes root mean square (rms) symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
j. Switchgear, switchboards, motor-control centers, and panelboards ampacity, and SCCR in amperes rms symmetrical.
k. Identify series-rated interrupting devices for condition where available fault current is greater than interrupting rating of downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

2. Examine the Project's overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance of the Work. Devices to be coordinated are indicated on Drawings.
3. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

C. Preparation of Data for Arc-Flash Hazard Study:

1. Assemble data from short-circuit study and overcurrent protective device coordination study.
2. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.3 SHORT-CIRCUIT STUDY

A. Base study on device characteristics supplied by device manufacturer.

B. Extent of electrical power system to be studied is indicated on Drawings.

C. Begin short-circuit current analysis at service, extending down to system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 5 kA or less.
2. Exclude equipment supplied by single transformer smaller than 75 kVA.

D. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for the Project. Study cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

E. Include AC fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase AC systems. Also account for fault-current DC decrement to address asymmetrical requirements of interrupting equipment.

F. Calculate short-circuit momentary and interrupting duties for three-phase bolted fault and single line-to-ground fault at equipment indicated on one-line diagram.

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

G. Include in report identification of protective device applied outside its capacity.

3.4 OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

A. Base study on device characteristics supplied by device manufacturer. When analysis of full range of device is impractical, limiting scope of analysis from 10 to 100 percent of device range is acceptable.

B. Extent of electrical power system to be studied is indicated on Drawings.

C. Begin analysis at service, extending down to system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 5 kA or less.

D. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for the Project. Study cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

E. Transformer Primary Overcurrent Protective Devices:

1. Device must not operate in response to the following:

a. Inrush current when first energized.
b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
c. Permissible transformer overloads in accordance with IEEE C57.96 if required by unusual loading or emergency conditions.

2. Device settings must protect transformers in accordance with IEEE C57.12.00, for fault currents.

F. Motor Protection:

1. Select protection for low-voltage motors in accordance with IEEE 3004.8 and NFPA 70.
2. Select protection for motors served at voltages more than 600 V in accordance with IEEE 620.

G. Conductor Protection: Protect cables against damage from fault currents in accordance with ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 3004.7. Demonstrate that equipment withstands maximum short-circuit current for time equivalent to tripping time of primary relay protection or total clearing time of fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

H. Generator Protection: Select protection in accordance with manufacturer's published instructions and IEEE C37.102.

I. Include AC fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase AC systems. Also account for fault-current DC decrement, to address asymmetrical requirements of interrupting equipment.

J. Include coordination of ground-fault protection devices.

K. Calculate short-circuit momentary and interrupting duties for three-phase bolted fault and single line-to-ground fault at equipment indicated on one-line diagram.

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

L. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare short-circuit ratings.
2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.

3. Application of series-rated devices must be recertified, complying with requirements in NFPA 70.
4. Include in report identification of protective device applied outside its capacity.

3.5 LOAD-FLOW AND VOLTAGE-DROP STUDY

A. Perform load-flow and voltage-drop study to determine steady-state loading profile of system. Analyze power system performance two times as follows:

1. Determine load flow and voltage drop based on full-load currents.
2. Determine load flow and voltage drop based on 80 percent of design capacity of load buses.
3. Prepare load-flow and voltage-drop analysis and report to show power system components that are overloaded or might become overloaded; show bus voltages that are less than as prescribed by NFPA 70.

3.6 MOTOR-STARTING STUDY

A. Perform motor-starting study to analyze transient effect of system's voltage profile during motor starting. Calculate significant motor-starting voltage profiles and analyze effects of motor starting on power system stability.

B. Prepare motor-starting study report, noting light flicker for limits proposed by IEEE 1453, and voltage sags so as not to affect operation of other utilization equipment on system supplying motor.

3.7 ARC-FLASH HAZARD STUDY

A. Comply with NFPA 70E, including Annex D, for arc-flash hazard study.

B. Preparatory Studies: Obtain short-circuit study and overcurrent protective device coordination study results prior to starting arc-flash hazard study.

C. Calculate maximum and minimum contributions of fault-current size.

1. Maximum calculation must assume maximum contribution from utility and must assume motors to be operating under full-load conditions.
2. Calculate arc-flash energy at 85 percent of maximum short-circuit current in accordance with IEEE 1584 recommendations.
3. Calculate arc-flash energy at 38 percent of maximum short-circuit current in accordance with NFPA 70E recommendations.
4. Calculate arc-flash energy with utility contribution at minimum and assume no motor contribution.

D. Calculate arc-flash protection boundary and incident energy at locations in electrical distribution system where personnel could perform work on energized parts.

E. Include medium- and low-voltage equipment locations except nominal arc-flash hazard warning data may be provided for equipment fed from transformers rated below 240 V(ac), 2000 A, instead of documenting precise calculations.

F. Calculate limited, restricted, and prohibited approach boundaries for each location.

G. Incident energy calculations must consider accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations must account for changing current contributions, as sources are interrupted or decremented with time. Fault contribution from motors and generators must be decremented as follows:

1. Fault contribution from induction motors must not be considered beyond three to five cycles.
2. Fault contribution from synchronous motors and generators must be decayed to match actual decrement of each as closely as possible (for example, contributions from permanent magnet generators will typically decay from 10 to 3 p.u. after 10 cycles).

H. Arc-flash energy must generally be reported for maximum of line or load side of circuit breaker. However, arc-flash computation must be performed and reported for both line and load side of circuit breaker as follows:

1. When circuit breaker is in separate enclosure.
2. When line terminals of circuit breakers are separate from work location.

I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.8 POWER SYSTEM STUDY REPORTS

A. Preparation of Power System Study Reports: Prepare and submit the following:

1. Short-Circuit Study Report Contents:

   a. Executive summary of study findings.
   b. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
   c. One-line diagram of modeled power system, showing the following:

      1) Protective device designations and ampere ratings.
      2) Conductor types, sizes, and lengths.
      3) Transformer kVA and voltage ratings.
      4) Motor and generator designations and kVA ratings.
      5) Switchgear, switchboard, motor-control center, and panelboard designations and ratings.
      6) Derating factors and environmental conditions.
      7) Revisions to electrical equipment required by study.

   d. Comments and recommendations for system improvements or revisions in written documents, separate from one-line diagram.
   e. Short-Circuit Study Input Data:

      1) One-line diagram of system being studied.
      2) Power sources available.
      3) Manufacturer, model, and interrupting rating of protective devices.
      4) Conductors.
      5) Transformer data.

   f. Protective Device Evaluation:

      1) Evaluate equipment and protective devices and compare them to available short-circuit currents. Verify that equipment withstand ratings exceed available short-circuit current at equipment installation locations.
      2) Tabulations of circuit breakers, fuse, and other protective device ratings versus calculated short-circuit duties.
      3) For 600 V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
      4) For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in standards to 1/2-cycle symmetrical fault current.
      5) Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

g. Short-Circuit Study Output Reports:

1) Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a) Voltage.
b) Calculated fault-current magnitude and angle.
c) Fault-point X/R ratio.
d) Equivalent impedance.

2) Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a) Voltage.
b) Calculated symmetrical fault-current magnitude and angle.
c) Fault-point X/R ratio.
d) Calculated asymmetrical fault currents based on fault-point X/R ratio; based on calculated symmetrical value multiplied by 1.6; and based on calculated symmetrical value multiplied by 2.7.

3) Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a) Voltage.
b) Calculated symmetrical fault-current magnitude and angle.
c) Fault-point X/R ratio.
d) No AC Decrement (NACD) ratio.
e) Equivalent impedance.
f) Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on symmetrical basis.
g) Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on total basis.

2. Overcurrent Protection Device Coordination Study Report Contents:

a. Executive summary of study findings.
b. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
c. One-line diagram of modeled power system, showing the following:

1) Protective device designations and ampere ratings.
2) Conductor types, sizes, and lengths.
3) Transformer kVA and voltage ratings.
4) Motor and generator designations and kVA ratings.
5) Switchgear, switchboard, motor-control center, and panelboard designations.
6) Revisions to electrical equipment required by study.

d. Report recommended settings of protective devices, ready to be applied in field. Use manufacturer's data sheets for recording recommended setting of overcurrent protective devices when available.

1) Phase and Ground Relays:

a) Device tag.
b) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
c) Recommendations on improved relaying systems, if applicable.

2) Circuit Breakers:

a) Adjustable pickups and time delays (long time, short time, and ground).
b) Adjustable time-current characteristic.
c) Adjustable instantaneous pickup.
d) Recommendations on improved trip systems, if applicable.

3) Fuses: Show current rating, voltage, and class.

e. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for switching schemes and for emergency periods where power source is local generation. Show the following information:

1) Device tag and title, one-line diagram with legend identifying portion of system covered.
2) Terminate device characteristic curves at point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.
3) Identify device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
4) Plot the following listed characteristic curves, as applicable:

a) Power utility's overcurrent protective device.
b) Medium-voltage equipment overcurrent relays.
c) Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
d) Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
e) Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
f) Cables and conductors damage curves.
g) Ground-fault protective devices.
h) Motor-starting characteristics and motor damage points.
i) Generators short-circuit decrement curve and generator damage point.
j) Largest feeder circuit breaker in each motor-control center and panelboard.

5) Maintain selectivity for tripping currents caused by overloads.
6) Maintain maximum achievable selectivity for tripping currents caused by overloads on series-rated devices.
7) Provide adequate time margins between device characteristics such that selective operation is achieved.

8) Comments and recommendations for system improvements.

3. Arc-Flash Hazard Study Report Contents:

a. Executive summary of study findings.
b. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
c. One-line diagram, showing the following:

1) Protective device designations and ampere ratings.
2) Conductor types, sizes, and lengths.
3) Transformer kVA and voltage ratings, including derating factors and environmental conditions.
4) Motor and generator designations and kVA ratings.
5) Switchgear, switchboard, motor-control center, panelboard designations, and ratings.

d. Short-circuit study output data.
e. Overcurrent protective device coordination study report contents.
f. Arc-Flash Study Output Reports:

1) Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each equipment location included in report:

a) Voltage.
b) Calculated symmetrical fault-current magnitude and angle.
c) Fault-point X/R ratio.
d) No AC Decrement (NACD) ratio.
e) Equivalent impedance.
f) Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on symmetrical basis.
g) Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on total basis.

g. Incident Energy and Flash Protection Boundary Calculations:

1) Arcing fault magnitude.
2) Protective device clearing time.
3) Duration of arc.
4) Arc-flash boundary.
5) Restricted approach boundary.
6) Limited approach boundary.
7) Working distance.
8) Incident energy.
9) Hazard risk category.
10) Recommendations for arc-flash energy reduction.

h. Fault study input data, case descriptions, and fault-current calculations including definition of terms and guide for interpretation of computer printout.

3.9 FIELD ADJUSTMENT FOR DEVICE COORDINATION

A. Adjust relay and protective device settings in accordance with recommended settings provided by coordination study. Field adjustments must be completed by engineering service division of equipment manufacturer under "Startup and Acceptance Testing" contract portion.

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

C. Testing and adjusting must be done by qualified medium-voltage and ow-voltage electrical testing and inspecting agency.

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for adjustable overcurrent protective devices.

3.10 WARNING LABELING OF ARC-FLASH HAZARDS

A. Apply **one** arc-flash label on front cover of each section of equipment and on side or rear covers with accessible live parts and hinged doors or removable plates for each equipment included in study, including each piece of equipment listed below:

1. Medium-voltage switchgear.
2. Medium-voltage switches.
3. Medium voltage transformers.
4. Switchboards.
5. Panelboards.
6. Motor-control centers.
7. Safety switches.
8. Control panels.

B. Base arc-flash label data on highest values calculated at each location.

C. Machine print warning labels with no handwritten or field-applied markings.

D. Install arc-flash warning labels under direct supervision and control of qualified professional electrical engineer.

E. Indicate on record Drawings location of equipment where personnel could be exposed to arc-flash hazard during their work.

1. Indicate arc-flash energy.
2. Indicate protection level required.

END OF SECTION 260573

SECTION 261326 - MEDIUM-VOLTAGE METAL-CLAD SWITCHGEAR

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes outdoor metal-clad switchgear.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustic, and other field conditions applicable to Work specified in this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each medium-voltage, metal-clad switchgear.

1. Include a tabulation of installed devices with features and ratings.
2. Include dimensioned plans and elevations, showing dimensions, shipping sections, and weights of each assembled section. Elevations must show major components, features, and mimic bus diagrams.
3. Include a plan view and cross section of equipment base showing clearances, manufacturer's recommended workspace, and locations of penetrations for grounding and conduits. Show location of anchor bolts and leveling channels.
4. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, and location and size of each field connection.
5. Locate accessory and spare equipment storage.
6. Include single-line diagram.
7. Include control power wiring diagrams.

8. Utility company's metering provisions with indication of approval by utility company.
9. Design Calculations:
   - Electrical drawings: Signed and sealed by a qualified professional electrical engineer in the State of California (Power)
   - Seismic restraints drawings: Signed and sealed by a qualified structural professional engineer in the State of California. Calculate requirements for selecting seismic restraints.
10. Relay settings.
11. Interface data with monitoring or control network.
12. Wiring Diagrams: For each switchgear assembly include the following:

    a. Power, signal, and control wiring.

b. Three-line diagrams of current and future secondary circuits showing device terminal numbers and internal diagrams.
c. Schematic control diagrams.
d. Diagrams showing connections of component devices and equipment.
e. Schematic diagrams showing connections to remote devices including connection details to the communications network.

1.3 INFORMATIONAL SUBMITTALS

A. Product certificates.

B. Source quality-control reports.

C. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Manufactured Unit: outdoor, metal-clad switchgear, designed for application in solidly grounded neutral system.

B. Comply with IEEE ANSI C37.20.2.

C. The switchgear ratings must comply with IEEE ANSI C37.04 and must be the preferred ratings of IEEE ANSI C37.06.

D. Switchgear Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory, and marked for intended location and application.

2.2 SWITCHGEAR ENCLOSURE

A. Outdoor Enclosure: Weatherproof, galvanized steel, designed for installation outdoors. With full-height doors, with provisions for padlocking. With an integral structural-steel base frame with factory-applied asphaltic undercoating. The enclosure must meet IEEE ANSI C37.20.2 Annex A, Category A enclosure requirements.

1. Each vertical section must have the following features:

a. Structural design and anchorage adequate to resist loads imposed by 125 mph (200 km/h)wind.
b. Space heater operating at one-half or less of rated voltage, sized to prevent condensation, controlled by thermostats to maintain temperature of each section above expected dew point.
c. Louvers equipped with insect and rodent screens and filters and arranged to permit air circulation while excluding rodents and exterior dust.
d. Weatherproof ground-fault circuit interrupter duplex receptacles.

e. Power for heaters and receptacles must be provided by control power transformer as indicated.
f. Skid Mounted: Mount each shipping group on an integral base frame as a complete weatherproof unit.

B. Enclosure Finish:

1. Outdoor Finish: Factory-applied finish in manufacturer's standard color, including under surfaces treated with corrosion-resistant undercoating.
2. Indoor Finish: Factory-applied finish in manufacturer's standard gray over a rust-inhibiting primer on treated metal surface.

2.3 SWITCHGEAR CONSTRUCTION

A. Deadfront, metal-clad, drawout, switchgear assembly of vertical sections, with vacuum circuit breakers. Provide additional vertical sections to house accessories related to the switchgear functions.

1. Front and rear access switchgear.
2. Front and rear vertical section covers with full-length hinges. The front cover must be a flanged door with latching hardware. The rear cover may be bolted.
3. Switchgear must be arc resistant, complying with IEEE ANSI C37.20.7.

B. Bus: Tin plated copper.

1. Ground Bus: Sized to carry the rated short time withstand current, extended full length of the switchgear assembly, and connected to the metal enclosures of each vertical section.

C. Circuit Breaker Compartments: Include a racking mechanism, circuit breaker operated automatic shutters covering the high-voltage bus connections, safety interlocks, and an electrical racking motor and accessories for remote racking of the circuit breaker.

D. Auxiliary Vertical Sections and Compartments:

1. Utility metering compartment that complies with utility company requirements.
2. Owner's Metering: A vertical section with a front hinged door for isolated access to meters and associated terminal and fuse blocks for maintenance, calibration, or testing while the gear is energized.

E. Circuit Breakers: Horizontally mounted, drawout, vacuum circuit breakers, operated by a motor-charged stored-energy mechanism, and having manual means of charging the mechanism.

1. Electrically Operated: 230 V(ac) close, ac capacitor trip. Powered from a fused control transformer integral to the switchgear.
2. Electrically Operated: 240 V(dc) close and trip. Powered from an external power source.

F. Accessory Set: Tools and miscellaneous items required for interrupter switchgear test, inspection, maintenance, and operation.

1. One of each size handling device to remove the circuit breaker from metal-clad switchgear and to move the breaker about on the floor.
2. Test cabinet with accessories to connect to the secondary contacts on an electrically operated removable element, permitting operation and testing of the removable element when it is removed from the housing.

G. Capacities and Characteristics:

1. Comply with IEEE ANSI C37.06.
2. Switchgear Assembly: (values to be confirmed with Engineer of Record)

a. Rated Maximum Design Voltage and BIL (Dielectric Test): 4.76 kV, 60 kV
b. Rated Continuous Current: 2000 A
c. Rated Short-Circuit Current and Short-Time Current: 40 kA RMS

d. Same capacities and characteristics as the switchgear assembly, and as follows:

1) Rated Continuous Current and Load Switching Current: 2000 A
2) Rated Closing and Latching Current: 104 kA, peak
3) Rated Interrupting Time: 50 ms

2.4 SURGE ARRESTERS

A. Comply with IEEE ANSI C62.11, distribution class; metal-oxide-varistor type, connected in each phase of incoming circuit and ahead of disconnecting device.

2.5 INSTRUMENTS

A. Instrument Transformers: Comply with IEEE ANSI C57.13.

1. Potential Transformers: Secondary voltage rating of 120 V and NEMA C 12.11 accuracy class of 0.3 with burdens of W, X, and Y.
2. Current Transformers: Burden and accuracy class suitable for connected relays, meters, and instruments..

B. Multifunction Digital Meter and Monitor: Microprocessor-based unit suitable for three- or four-wire systems.

1. Inputs from sensors or 5 A current-transformer secondaries, and potential terminals rated to 600 V.
2. Switch-selectable digital display with the following features:

a. Phase Currents, Each Phase: Plus or minus 1 percent.
b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
d. Three-Phase Real Power: Plus or minus 2 percent.
e. Three-Phase Reactive Power: Plus or minus 2 percent.
f. Power Factor: Plus or minus 2 percent.
g. Frequency: Plus or minus 0.5 percent.

h. Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
i. Accumulated energy, in megawatt-hours (megajoules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

3. Mounting: Display and control unit that is flush or semiflush mounted in instrument compartment door.

C. Analog Instruments: Rectangular, 4-1/2 inch (115 mm) square, 1 percent accuracy, semiflush mounting, with anti-parallax 250-degree scale and external zero adjustment.

1. Voltmeters: Cover an expanded scale range of normal voltage plus 10 percent.
2. Voltmeter Selector Switch: Rotary type with off position to provide readings of phase-to-phase **and phase-to-neutral** voltages.
3. Ammeters: Cover an expanded scale range of bus rating plus 10 percent.
4. Ammeter Selector Switch: Permits current reading in each phase and keeps current-transformer secondary circuits closed in off position.
5. Locate meter and selector switch on circuit-breaker compartment door for indicated feeder circuits only.
6. Watt-Hour Meters: Flush- or semiflush-mounting type, 5 A, 120 V, three phase, three wire; with three elements, **15-minute** indicating demand register, and provision for testing and adding pulse initiation.
7. Recording Demand Meter: Usable as totalizing relay or indicating and recording maximum demand meter with **15-minute** interval.

a. Operation: Counts and records a succession of pulses entering two channels.
b. Housing: Drawout, back-connected case arranged for semiflush mounting.

2.6 PROTECTIVE RELAYS

A. Multifunctional, solid-state microprocessor-based relay systems, complying with IEEE ANSI C37.90.

B. Relay Mounting:

1. Each relay must be mounted in a drawout case with a two-stage quick-release operation.
2. Removal of the relay from the case must disconnect the trip circuits and short the current-transformer secondaries before the unit control power is disconnected.
3. When the relay is inserted into the case, control power connections must be made before the trip circuits are activated.
4. Include a self-shorting contact on the case terminal block for alarm indication and tripping of circuit breaker upon removal of the relay from the case.

C. Overcurrent and Ground-Fault Protective Relays:

1. IEEE ANSI C37.2 device functions 51/50 and 51/50N.
2. Field-Selectable Relay Settings: Required by the overcurrent protective device coordination study and arc-flash study.
3. Primary Current-Transformer Ratings: Programmable from 5 to 5000 A.
4. Phase and Ground Protection: Field-selectable curves from IEEE moderately inverse, very inverse, or extremely inverse.

5. Phase Instantaneous Overcurrent Trip Pickup Point: Field selectable as "none" or from 1.0 to 25 times current-transformer primary rating. Include discriminator circuit with "on" and "off" switch so that when phase instantaneous overcurrent has been programmed to "none," the discriminator circuit protects against currents exceeding 11 times current-transformer primary rating when the breaker is being closed and must be deactivated after approximately eight cycles.
6. Contacts:

    a. Two Form-A contacts.
    b. Field selectable into contact pairs as follows and as required by the overcurrent protective device coordination study and arc-flash study:

        1) One contact assigned function 51 phase and function 51 ground, and the other contact assigned function 50 phase and function 50 ground.
        2) One contact assigned function 51/50 phase, and the other contact assigned function 51/50 ground.

7. Alphanumeric display to show the following parameters with metering accuracy not to exceed 2 percent of full scale:

    a. Individual phase currents.
    b. Ground current.
    c. Cause of trip.
    d. Magnitude and phase of current-causing trip.
    e. Phase or ground indication.
    f. Peak current demand for each phase and ground since last reset.
    g. Current-transformer primary rating.
    h. Programmed phase and ground set points.

8. Relay alarm and trip contacts must not change state if power is lost or an undervoltage occurs. These contacts must only cause a trip on detection of an overcurrent or fault condition based on programmed settings. A "protection off" alarm must be normally energized when the relay is powered and the self-diagnostics indicates the unit is functional. On loss of power or relay failure, this alarm relay must be de-energized, providing a fail-safe protection off alarm.

2.7 AC CONTROL POWER SUPPLY

A. Description: Control power transformer must supply 120 V(ac) control circuits through secondary disconnect and overcurrent protective devices.

1. Dry-type transformer, in separate compartment, with primary and secondary fuses to provide current-limiting and overload protection.
    a. AC Power Supply: 120 V, 60 Hz, subject to plus or minus 10 percent variation in

2.8 WARNING LABELS AND SIGNS

A. Install appropriate precautionary labels to warn about potential hazards that are inherent to the equipment. Comply with requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."

1. Warning signs must be baked enamel signs.
2. Equipment Identification Labels: Laminated acrylic or melamine plastic signs

2.9 SOURCE QUALITY CONTROL

A. Perform production tests on each circuit breaker housing for this Project, complying with IEEE ANSI C37.09.

1. Perform mechanical operation tests to ensure proper functioning of shutters, operating mechanism, mechanical interlocks, and interchangeability of removable elements that are designed to be interchangeable.
2. Conduct an alignment test with master circuit breaker to verify interfaces.
3. Verify that control wiring is correct by verifying continuity. Perform electrical operation of relays and devices to ensure they function properly and in the intended sequence.
4. Perform the control wiring dielectric test at 1500 V for one minute.
5. Perform the dielectric test on primary and secondary circuits.

B. Perform production tests, on each circuit breaker supplied for this Project, complying with IEEE ANSI C37.09.

1. Perform mechanical operation tests to ensure proper functioning of the switch.
2. Conduct an alignment test with master cells to verify interfaces and interchangeability.
3. Verify the contact gap. Perform terminal-to-terminal resistance test.
4. Verify that control wiring is correct by verifying continuity. Perform electrical operation of relays and devices to ensure they function properly and in the intended sequence. Operate the circuit breakers over the range of minimum to maximum control voltage.
5. Perform the control wiring dielectric test at 1500 V for one minute.
6. Set the contact gap.

PART 3 - EXECUTION

3.1 SWITCHGEAR INSTALLATION

A. Equipment Mounting:

1. Install switchgear on cast-in-place concrete equipment base.

B. Switchgear must be installed level and plumb. Switchgear must tilt less than 1.5 degrees while energized.

C. Maintain minimum clearances and workspace at equipment in accordance with manufacturer's instructions and NFPA 70.

D. Comply with NECA 430.

3.2 CONNECTIONS

A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

B. Grounding Connections at Interior Locations:

1. Install bare copper cable not smaller than No. 4/0 AWG for grounding-to-grounding electrodes.
2. Bond surge arrester and neutrals directly to the switchgear enclosure and then to the grounding electrode system with bare copper conductors.
3. Keep leads as short as practicable with no kinks or sharp bends.
4. Make joints in grounding conductors and loops by exothermic weld or compression connector.

C. Grounding at Exterior Locations:

1. Install tinned bare copper cable not smaller than No. 4/0 AWG, for counterpoise buried not less than 30 inch (765 mm) below grade interconnecting the grounding electrodes.
2. Bond surge arrester and neutrals directly to the switchgear enclosure and then to the grounding electrode system with bare copper conductors, sized as shown.
3. Keep lead lengths as short as practicable with no kinks or sharp bends.
4. Fence and equipment connections must not be smaller than No. 4 AWG.
5. Ground fence at each gate post and corner post and at intervals not exceeding 10 ft. (3 m).
6. Bond each gate section to the fence post using 1/8 by 1 inch (3 by 25 mm) flexible braided copper strap and clamps.
7. Make joints in grounding conductors and loops by exothermic weld or compression connector.

D. Terminate grounding and bonding conductors on a common equipment grounding terminal on the switchgear enclosure. Install supplemental terminal bars, lugs, and bonding jumpers as required to accommodate the number of conductors for termination.

E. Complete switchgear grounding and lightning arrester connections prior to making other electrical connections.

F. Terminate medium-voltage cables in accordance with Section 260513 "Medium-Voltage Cables."

3.3 SIGNS AND LABELS

A. Comply with the installation requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."

B. Install warning signs as required to comply with 29 CFR 1910.269.

3.4 FIELD QUALITY CONTROL

A. Field tests and inspections must be witnessed by authorities having jurisdiction.

B. General Field-Testing Requirements:

1. Comply with the provisions of NFPA 70B, "Testing and Test Methods."
2. After installing switchgear and after electrical circuitry has been energized, test for compliance with requirements.
3. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.

C. Medium-Voltage Switchgear Assembly Field Tests:

1. Visual and Mechanical Inspection:

a. Verify that fuse and circuit breaker sizes and types correspond to Drawings and coordination study.
b. Verify that current and voltage transformer ratios correspond to Drawings.
c. Inspect bolted electrical connections using calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
d. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

1) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
2) Make key exchange with devices operated in off-normal positions.

e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
f. Inspect insulators for evidence of physical damage or contaminated surfaces.
g. Verify correct barrier and shutter installation and operation.
h. Exercise active components.
i. Inspect mechanical indicating devices for correct operation.
j. Verify that filters are in place and vents are clear.
k. Perform visual and mechanical inspection of instrument transformers in accordance with "Instrument Transformer Field Tests" Paragraph.
l. Inspect control power transformers.

1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
2) Verify that primary and secondary fuse or circuit breaker ratings match drawings.
3) Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.

2. Electrical Tests:

a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

b. Perform dc voltage insulation-resistance tests on each bus section, phase to phase and phase to ground, for one minute. If the temperature of the bus is other than plus or minus 20 deg. C, adjust the resulting resistance as provided in NETA ATS, Table 100.11.

   1) Insulation-resistance values of bus insulation must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.
   2) Do not proceed to the dielectric withstand voltage tests until insulation-resistance levels are raised above minimum values.

c. Perform a dielectric withstand voltage test on each bus section, each phase to ground with phases not under test grounded, in accordance with manufacturer's published data. If manufacturer has no recommendation for this test, it must be conducted in accordance with NETA ATS, Table 100.2. Apply the test voltage for one minute.

   1) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.

d. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential must be 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable. Test duration must be one minute. For units with solid-state components or control devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.

   1) Minimum insulation-resistance values of control wiring must not be less than 2 megohms.

e. Control Power Transformers:

   1) Perform insulation-resistance tests. Perform measurements from winding to winding and each winding to ground. Insulation-resistance values of winding insulation must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.
   2) Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source. Verify correct potential at all devices.
   3) Verify correct secondary voltage by energizing the primary winding with system voltage. Measure secondary voltage with the secondary wiring disconnected.
   4) Verify correct function of control transfer relays located in the switchgear with multiple control power sources.

f. Voltage Transformers:

1) Perform secondary wiring integrity test. Verify correct potential at devices.
2) Verify secondary voltages by energizing the primary winding with system voltage.

g. Perform current-injection tests on the entire current circuit in each section of switchgear.

1) Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.

h. Perform system function tests in accordance with "System Function Tests" Article.
i. Verify operation of space heaters.
j. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from each source.

D. Medium-Voltage Vacuum Circuit Breaker Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, grounding, and required clearances.
c. Verify that maintenance devices such as special tools and gages specified by the manufacturer are available for servicing and operating the breaker.
d. Verify the unit is clean.
e. Perform mechanical operation tests on operating mechanisms in accordance with manufacturer's published data.
f. Measure critical distances on operating mechanism as recommended by the manufacturer. Critical distances of the operating mechanism must be in accordance with manufacturer's published data.
g. Verify cell fit and element alignment.
h. Verify racking mechanism operation.
i. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
j. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
k. Perform time-travel analysis. Travel and velocity values must be in accordance with manufacturer's published data.
l. Record as-found and as-left operation counter reading. Operation counter must advance one digit per close-open cycle.

2. Electrical Tests:

a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Insulation-resistance values must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate

and correct values of insulation resistance less than this table or manufacturer's recommendations. Dielectric-withstand-voltage tests must not proceed until insulation-resistance levels are raised above minimum values.

b. Perform a contact/pole-resistance test. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value. Microhm or dc millivolt drop values must not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

c. Perform minimum pickup voltage tests on trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of the trip and close coils must comply with manufacturer's published data. In the absence of the manufacturer's published data, comply with NETA ATS, Table 100.20.

d. Verify correct operation of auxiliary features, such as electrical close and trip operation, trip-free operation, and anti-pump function. Auxiliary features must operate in accordance with manufacturer's published data.

e. Trip circuit breaker by operation of each protective device. Reset trip logs and indicators.

f. Perform power-factor or dissipation-factor tests on each pole with the breaker open and each phase with the breaker closed. Power-factor or dissipation-factor values must comply with manufacturer's published data.

g. Perform vacuum bottle integrity (dielectric-withstand-voltage) test across each vacuum bottle, with the contacts in the "open" position in accordance with manufacturer's published data. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the vacuum bottle integrity test, the test specimen is considered to have passed the test.

h. Perform a dielectric-withstand-voltage test in accordance with manufacturer's published data. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric-withstand-voltage test, the test specimen is considered to have passed the test.

i. Verify operation of heaters.

E. Instrument Transformer Field Tests:

1. Visual and Mechanical Inspection:

a. Verify that equipment nameplate data complies with Contract Documents.

b. Inspect physical and mechanical condition.

c. Verify correct connection of transformers with system requirements.

d. Verify that adequate clearances exist between primary and secondary circuit wiring.

e. Verify the unit is clean.

f. Inspect bolted electrical connections using calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.

g. Verify that required grounding and shorting connections provide contact.

h. Verify correct operation of transformer withdrawal mechanism and grounding operation.

i. Verify correct primary and secondary fuse sizes for voltage transformers.

j. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

2. Electrical Tests of Current Transformers:

a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Perform insulation-resistance test of each current transformer and its secondary wiring with respect to ground at 1000 V(dc) for one minute. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's recommendations. Investigate and correct values of insulation resistance less than manufacturer's written recommendations or NETA ATS, Table 100.5.
c. Perform a polarity test of each current transformer in accordance with IEEE ANSI C57.13.1. Polarity results must agree with transformer markings.
d. Perform insulation-resistance tests on the primary winding with the secondary grounded. Test voltages must be in accordance with Table 100.5.
e. Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data.
f. Verify that current transformer secondary circuits are grounded and have only one grounding point in accordance with IEEE ANSI C57.13.3. That grounding point should be located as specified by the engineer in the project drawings.

3. Electrical Tests of Voltage Transformers.

a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Perform insulation-resistance tests winding-to-winding and each winding to ground. Test voltages must be applied for one minute in accordance with Table 100.5. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's recommendations. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.5.
c. Perform a polarity test on each transformer to verify the polarity marks or H1-X1 relationship as applicable. Polarity results must agree with transformer markings.

F. Ground Resistance Test

1. Visual and Mechanical Inspection:

a. Verify ground system complies with Contract Documents and NFPA 70 Article 250, "Grounding and Bonding."
b. Inspect physical and mechanical condition. Grounding system electrical and mechanical connections must be free of corrosion.
c. Inspect bolted electrical connections using calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.
d. Inspect anchorage.

2. Electrical Tests.

a. Perform fall-of-potential or alternative test in accordance with IEEE Std 81 on the main grounding electrode or system. The resistance between the main grounding electrode and ground must be no more than 5 ohms.
b. Perform point-to-point tests to determine the resistance between the main grounding system and major electrical equipment frames, system neutral, and derived neutral points. Investigate point-to-point resistance values that exceed 0.5 ohm. Compare equipment nameplate data with Contract Documents.
c. Inspect physical and mechanical condition.
d. Inspect bolted electrical connections for high resistance using a low-resistance ohmmeter to compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

G. Metering Devices Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect bolted electrical connections using calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.
c. Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case shorting contacts, as applicable.
d. Verify the unit is clean.
e. Verify freedom of movement, end play, and alignment of rotating disk(s).

2. Electrical Tests:

a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Verify accuracy of meters at cardinal points. Meter accuracy must be in accordance with manufacturer's published data.
c. Calibrate meters in accordance with manufacturer's published data. Calibration results must be within manufacturer's published tolerances.
d. Verify instrument multipliers. Instrument multipliers must be in accordance with system design specifications.
e. Verify that current transformer and voltage transformer secondary circuits are intact. Test results must confirm the integrity of the secondary circuits of current and voltage transformers.

H. Medium-Voltage Surge Arrester Field Tests:

1. Visual and Mechanical Inspection:

a. Verify that equipment nameplate data complies with Contract Documents.
b. Inspect physical and mechanical condition.

c. Inspect anchorage, alignment, grounding, and clearances.
d. Verify the arresters are clean.
e. Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
f. Verify that the stroke counter is correctly mounted and electrically connected if applicable. Record the stroke counter reading.

2. Electrical Test:

a. Perform an insulation-resistance test on each arrester, phase terminal-to-ground. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Replace units that fail to meet recommended minimum insulation resistance listed in the table.
b. Perform a watts-loss test. Evaluate watts-loss values by comparison with similar units and test equipment manufacturer's published data.
c. Test grounding connections. Resistance between the arrester ground terminal and the ground system must be less than 0.5 ohm.

I. Microprocessor-Based Protective Relay Field Tests:

1. Visual and Mechanical Inspection:

a. Record model number, style number, serial number, firmware revision, software revision, and rated control voltage.
b. Verify operation of light-emitting diodes, display, and targets.
c. Record passwords for each access level.
d. Clean the front panel and remove foreign material from the case.
e. Check tightness of connections.
f. Verify that the frame is grounded in accordance with manufacturer's instructions.
g. Set the relay in accordance with results in Section 260573.16 "Coordination Studies" and in Section 260573.19 "Arc-Flash Hazard Analysis."
h. Download settings from the relay. Print a copy of the settings for the report and compare the settings to those specified in the coordination study.

2. Electrical Tests:

a. Perform insulation-resistance tests from each circuit to the grounded frame in accordance with manufacturer's published data.
b. Apply voltage or current to analog inputs and verify correct registration of the relay meter functions.
c. Functional Operation: Check functional operation of each element used in the protection scheme as follows:

1) Timing Relay:

a) Determine time delay.
b) Verify operation of instantaneous contacts.

2) Volts/Hertz Relay:

a) Determine pickup frequency at rated voltage.

b) Determine pickup frequency at a second voltage level.
c) Determine time delay.

3) Sync Check Relay:

a) Determine closing zone at rated voltage.
b) Determine maximum voltage differential that permits closing at zero degrees.
c) Determine live line, live bus, dead line, and dead bus set points.
d) Determine time delay.
e) Verify dead bus/live line, dead line/live bus, and dead bus/dead line control functions.

4) Undervoltage Relay:

a) Determine dropout voltage.
b) Determine time delay.
c) Determine time delay at a second point on the timing curve for inverse time relays.

5) Directional Power Relay:

a) Determine minimum pickup at maximum torque angle.
b) Determine closing zone.
c) Determine maximum torque angle.
d) Determine time delay.
e) Verify time delay at a second point on the timing curve for inverse time relays.

6) Current Balance Relay:

a) Determine pickup of each unit.
b) Determine percent slope.
c) Determine time delay.

7) Negative Sequence Current Relay:

a) Determine negative sequence alarm level.
b) Determine negative sequence minimum trip level.
c) Determine maximum time delay.
d) Verify two points on the I-two-squared-t curve.

8) Phase Sequence or Phase Balance Voltage Relay:

a) Determine positive sequence voltage to close the NO contact.
b) Determine positive sequence voltage to open the NC contact (undervoltage trip).
c) Verify negative sequence trip.
d) Determine time delay to close the NO contact with sudden application of 120 percent of pickup.

e) Determine time delay to close the NC contact upon removal of voltage when previously set to rated system voltage.

9) Instantaneous Overcurrent Relay:

a) Determine pickup.
b) Determine dropout.

d. Control Verification:

1) Functional Tests:

a) Check operation of active digital inputs.
b) Check output contacts or silicone-controlled rectifiers (SCRs), preferably by operating the controlled device, such as circuit breaker, auxiliary relay, or alarm.
c) Check internal logic functions used in protection scheme.
d) Upon completion of testing, reset min/max recorders, communications statistics, fault counters, sequence-of-events recorder, and event records.

2) In-Service Monitoring: After the equipment is initially energized, measure magnitude and phase angle of inputs and verify expected values.

J. Switchgear will be considered defective if it does not pass tests and inspections.

1. Remove and replace defective units and retest.

K. Prepare test and inspection reports. Record as-left set points of adjustable devices.

3.5 SYSTEM FUNCTION TESTS

A. System function tests must prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality control tests have been completed and components have passed specified tests.

1. Develop test parameters and perform tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
2. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
3. Verify the correct operation of sensing devices, alarms, and indicating devices.

END OF SECTION 261326