

SECTION 16010  
GENERAL ELECTRICAL

PART 1 - GENERAL

1.01 SCOPE

A. Work shall include, but shall not be limited to, the following:

1. Testing all of the existing electrical equipment, which is scheduled to remain in the building and reporting any found deficiencies to the owner.
2. Main secondary electrical service.
3. Temporary power as required.
4. Seismic restraints as specified in Section 15000.
5. Underground ductbank and manhole system.
6. Temporary 500 kW, 480/277V Generator and temporary connections as required.
7. Fuel for temporary Generator as required.
8. Secondary switchboard.
9. Ground fault protection on mains.
10. Short circuit protection and coordination study.
11. Motor starters.
12. Motor connections and controls.
13. Standby emergency generator systems.
14. Automatic transfer switches.
15. Panelboards, circuit breakers.
16. Dry type transformers.
17. Safety disconnect switches (fused or unfused).
18. Fuses.
19. Lighting fixtures including lamps and fuses as required.
20. Fluorescent ballasts.
21. Conduit and raceways.
22. Wire and cable.
23. Branch circuit wiring.
24. Telephone conduit and outlet system.
25. Wiring devices and plates.
26. Fire seal, (and) fireproof foam.
27. Sleeving.
28. Pull boxes and cable troughs.
29. Building system grounding.
30. Fire alarm system, devices and FACP modifications, to accommodate new devices.
31. Access panels.
32. Supervision and approval.
33. Cutting and patching related to electrical work.
34. Relocating certain parts of existing electrical work.
35. Electrical connections to HVAC and Plumbing equipment, and other equipment provided under other Sections or by Owner.
36. Relocation of existing electrical components that interfere with new construction as determined by Architect; removal and disposal of obsolete components.
37. Nameplates, labels and tags.
38. Other systems and equipment as indicated on the drawings.
39. Testing.
40. Operating and maintenance instructions and manuals.
41. Coordination drawings and shop drawings.

- B. Furnish items for installation under other Sections or by Owner, and wire as required:
  - 1. Emergency generator exhaust silencer and flexible connection(s) for installation under other sections.
  - 2. Electric solenoid valve on generator fuel line for installation under other sections.
  
- C. Remove, extend, alter and reconnect existing conduits as directed by Architect. Reconnect existing conduit that is cut or disconnected to accommodate work. Pull in new wires between nearest accessible outlets intended for reuse. Provide new conduit where wire cannot be pulled in existing. Connect new and existing work to function as complete, continuously grounded system. Remove conduit and equipment not intended for reuse and store where directed. Use conduit exposed by Work of the Contract in conjunction with nearest outlet intended for reuse as directed.

#### 1.02 CONTRACT DOCUMENTS

- A. Work to be performed under this Section is in conjunction with work shown on the drawings.

#### 1.03 RELATED WORK IN OTHER SECTIONS

- A. The following work is not included in this Section.
  - 1. Motors will be furnished and set in place under other Sections.
  - 2. Structural supports necessary to distribute loading from equipment to roof or floor except as specified.
  - 3. Telephone system, wire, cable, equipment and instruments.
  - 4. Automatic temperature control wiring except as noted on Drawings.
  - 5. Emergency generator engine exhaust duct and pipe and installation of flexible connections and muffler.
  - 6. Emergency generator fuel tank piping, pumps, fuel line fittings and connections to day tank and transfer pump.
  - 8. Emergency generator fuel storage tank level alarm (wire under this Section to generator annunciator panel).

#### 1.04 SUBMITTALS

- A. Material and equipment requiring Shop Drawing Submittals shall include but not be limited to:
  - 1. Main secondary electrical service.
  - 2. Underground ductbank system.
  - 3. Secondary switchboards.
  - 4. Ground fault protection on mains and sub-mains.
  - 5. Short-circuit protection and coordination study.
  - 6. Motor starters.
  - 7. Standby emergency generator system.
  - 8. Automatic transfer switches.
  - 9. Temporary Generator connection box..
  - 10. Panelboards, circuit breakers.
  - 11. Dry type transformers.
  - 12. Safety disconnect switches (fused or unfused).
  - 13. Fuses.
  - 14. Lighting fixtures including lamps and fuses as required.
  - 15. Fluorescent ballasts.
  - 16. Conduit and raceways.
  - 17. Wire and cable.

18. Branch circuit wiring.
19. Temporary power and light.
20. Telephone conduit and outlet system.
21. Wiring devices and plates.
22. Fire seal (and) (or) fire-proof foam.
23. Pull boxes and cable throughs.
24. Building system ground.

1.05 ADDITIONAL REQUIREMENTS OF ELECTRICAL CONTRACTOR

- A. All Contractors and Subcontractors bidding on work in this Section shall be required to review/tour site prior to submitting proposal.
- B. Temporary Connections
  1. Make temporary connections as required to maintain full electrical services during course of this project both within and outside project areas and whether or not these connections are shown on Drawings.
- C. Drawings
  1. Drawings are diagrammatic and are intended to convey only general system requirements.
  2. Contractor shall be responsible for providing a complete system, which has been approved by Owner, Architect, State/Local Fire Marshal and Owner's Insurance Underwriter, (Owner's Insurance Underwriter to be provided by Owner).
- D. Work coordination
  1. Electrical Contractor shall coordinate his work with General, Fire Protection, HVAC and Plumbing Contractors and shall make necessary adjustments or changes to facilitate installation of all Electrical equipment in spaces available.
  2. Electrical Contractor shall add to coordination drawings electrical equipment with dimensions above finished floor.
  3. Coordination drawings for any building area shall be complete with information from all trades and with all coordination issues resolved prior to mechanical or electrical construction beginning in that area.
  4. Electrical Contractor shall coordinate with General Contractor locations of all building structural elements prior to start of construction.
- E. Fire Watch
  1. When working with an open flame - i.e., soldering, brazing, welding or cutting with a torch - Contractor shall provide fire watch in accordance with requirements of the Municipality and adhere to following requirements:
    - a. Fire extinguisher, with current inspection, to be in possession of person performing "Hot Work" at all times.
    - b. Provide second person in vicinity of "Hot Work" to perform fire watch.
    - c. Electrical Contractor to contact Owner disable smoke detectors in immediate vicinity of "Hot Work" procedure. Upon completion of "Hot Work" procedure, smoke detector to be reactivated.
    - d. Provide temporary ventilation, as required, for removal of smoke generated by "Hot Work" procedures.

2. As required by OSHA and by accepted standards of safe practice, lock-out/tag-out all equipment required for protection against accidental or inadvertent operation when such operation could cause damage to equipment and/or personnel.
3. Notify General Contractor before instituting any lock-out/tag-out procedure.

F. Access to electrical installations

1. All electrical equipment, etc. shall be installed in strict accordance with manufacturer's instructions and installed with clearance for servicing. It is the Electrical Contractor's responsibility to insure that systems are installed with adequate clearance for servicing.
2. Drawings are diagrammatic. Electrical Contractor shall review equipment installation instructions to insure proper that clearances are maintained.
3. It is the responsibility of the Electrical Contractor to insure that access is maintained to Electrical installations. Electrical Contractor shall coordinate the work of other trades in the vicinity of Electrical installations requiring servicing to maintain adequate clearances for servicing.
4. Utilize spaces efficiently to maximize accessibility for other installations, maintenance and repairs.
5. Electrical Contractor shall notify Architect prior to installing equipment in inaccessible locations.
6. Any work requiring subsequent removal or replacement due to unsatisfactory or defective work, or work that is installed in a manner that is inaccessible for servicing, is the responsibility of the Electrical Contractor.
7. Architect and/or Owner shall determine if installations are accessible or inaccessible.

1.06 ACCESS PANELS

- A. Panels shall be provided by Electrical Contractor for all concealed junction boxes or any items requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced and maintained or completely removed and replaced. Minimum size of panel shall be 12" by 12". Panels shall be complete with identifying labels.
- B. Access panels to be constructed and installed to maintain integrity of fire barriers penetrated.
- C. Firestop
  1. Firestop shall be by 3M, Hilti, Johns Manville or Tremco.
  2. Firestop all new and existing Electrical penetrations of existing roofs, floor slabs, 1-hour rated partitions, 2-hour rated partitions and smoke partitions within and enveloping project spaces.
  3. At conclusion of firestopping work, inspect firestopping at each newly firestopped penetrations in all roofs, floor slabs and partitions. Each firestopped penetration shall be approved, by signature, by Electrical Contractor, Construction Manager and Owner prior to final acceptance of work by Owner. Letter of acceptance by authority having jurisdiction is acceptable.
  4. All contractors on project shall utilize the same manufacturer of firestop products.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 16010

SECTION 16050

BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following:
  - 1. Electrical equipment coordination and installation.
  - 2. Sleeves for raceways and cables.
  - 3. Sleeve seals.
  - 4. Common electrical installation requirements.

1.03 DEFINITIONS

- A. ATS: Acceptance Testing Specifications.
- B. EPDM: Ethylene-propylene-diene terpolymer rubber.
- C. NBR: Acrylonitrile-butadiene rubber.

1.04 SUBMITTALS

- A. Product Data: For each type of product indicated.

1.05 QUALITY ASSURANCE

- A. Test Equipment Suitability and Calibration: Comply with NETA ATS, "Suitability of Test Equipment" and "Test Instrument Calibration."

1.06 COORDINATION

- A. Coordinate arrangement, mounting, and support of electrical equipment:
  - 1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
  - 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
  - 3. To allow right of way for piping and conduit installed at required slope.
  - 4. To permit connecting raceways, cables, wireways, cable trays, and busways to be clear of obstructions and the working and access spaces of other equipment.
- B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 8 Section, "Access Doors and Frames."

- D. Coordinate electrical testing of electrical, mechanical, and architectural items, so equipment and systems that are functionally interdependent are tested to demonstrate successful interoperability.

## PART 2 - PRODUCTS

### 2.01 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

### 2.02 SLEEVES FOR RACEWAYS AND CABLES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch thickness as indicated and of length to suit application.
- D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 7 Section, "Through-Penetration Firestop Systems."

### 2.03 SLEEVE SEALS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
1. Suggested Manufacturers:
    - a. Advance Products & Systems, Inc.
    - b. Calpico, Inc.
    - c. Metraflex Co.
    - d. Pipeline Seal and Insulator, Inc.
  2. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
  3. Pressure Plates: Include two for each sealing element.
  4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating or Stainless steel, as required, of length required to secure pressure plates to sealing elements. Include one for each sealing element.

## PART 3 - EXECUTION

### 3.01 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

- A. Comply with NECA 1.
- B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounted items.

- C. **Headroom Maintenance:** If mounting heights or other location criteria is not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- D. **Equipment:** Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnection with minimum interference with other items in the vicinity.
- E. **Right of Way:** Yield to raceways and piping systems installed at a required slope.

### 3.02 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
- B. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 7 Section, "Through-Penetration Firestop Systems."
- C. **Concrete Slabs and Walls:** Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- D. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- E. **Rectangular Sleeve Minimum Metal Thickness:**
  - 1. For sleeve cross-section rectangle perimeter less than 50 inches and no side greater than 16 inches, thickness shall be 0.052 inch.
  - 2. For sleeve cross-section rectangle perimeter equal to, or greater than, 50 inches and 1 or more sides equal to, or greater than, 16 inches, thickness shall be 0.138 inch.
- F. **Fire-Rated Assemblies:** Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- G. Cut sleeves to length for mounting flush with both surfaces of walls.
- H. Extend sleeves installed in floors 2 inches above finished floor level.
- I. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable, unless sleeve seal is to be installed or unless seismic criteria require a different clearance.
- J. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.
- K. **Interior Penetrations of Non-Fire-Rated Walls and Floors:** Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Refer to Division 7 Section, "Joint Sealants" for materials and installation.
- L. **Fire-Rated-Assembly Penetrations:** Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with Division 7 Section, "Through-Penetration Firestop Systems."
- M. **Roof-Penetration Sleeves:** Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

- N. Aboveground, Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- O. Underground, Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

### 3.03 SLEEVE-SEAL INSTALLATION

- A. Install to seal underground, exterior wall penetrations.
- B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

### 3.04 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 7 Section, "Through-Penetration Firestop Systems."

### 3.05 FIELD QUALITY CONTROL

- A. Inspect installed sleeve and sleeve-seal installations and associated firestopping for damage and faulty work.

END OF SECTION 16050



SECTION 16055

OVERCURRENT PROTECTIVE DEVICE COORDINATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes computer-based, fault-current and overcurrent protective device coordination studies, and the setting of these devices.

1.03 SUBMITTALS

- A. Product Data: For computer software program to be used for studies.
- B. Product Certificates: For coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399.
- C. Qualification Data: For coordination-study specialist.
- D. Other Action Submittals:
  - 1. Coordination-study input data, including completed computer program input data sheets.
  - 2. Coordination-study report.
  - 3. Equipment evaluation report.
  - 4. Setting report.

1.04 QUALITY ASSURANCE

- A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.
- B. Coordination-Study Specialist Qualifications: An organization experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
- C. Testing Agency Qualifications: Member company of the International Electrical Testing Association.
  - 1. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association to supervise testing specified in Part 3.
- D. Comply with IEEE 399 for general study procedures.
- E. Comply with IEEE 242 for short-circuit currents and coordination time intervals.

## PART 2 - PRODUCTS

### 2.01 COMPUTER SOFTWARE DEVELOPERS

- A. Computer Software Developers: Subject to compliance with requirements, provide computer software programs developed by one of the following:
1. CYME International, Inc.
  2. EDSA Micro Corporation.
  3. Electrical Systems Analysis, Inc.
  4. SKM Systems Analysis, Inc.

### 2.02 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

- A. Comply with IEEE 399.
- B. Analytical features of fault-current-study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399, Table 7-4.
- C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices.
1. Optional Features:
    - a. Arcing faults.
    - b. Simultaneous faults.
    - c. Explicit negative sequence.
    - d. Mutual coupling in zero sequence.

## PART 3 - EXECUTION

### 3.01 EXAMINATION

- A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.
- B. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices not submitted for approval with coordination study may not be used in study.

### 3.02 FAULT-CURRENT STUDY

- A. Source Impedance: Utility Company's fault-current contribution as indicated.
- B. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project and use approved computer software program to calculate values. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.
- C. Calculate momentary and interrupting duties on the basis of maximum available fault current.

- D. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with the following:
1. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.50.
  2. Low-Voltage Fuses: IEEE C37.46.
  3. Circuit Breakers: IEEE C37.13.
- E. Study Report: Enter calculated X/R ratios and interrupting (5-cycle) fault currents on electrical distribution system diagram of the report. List other output values from computer analysis, including momentary (1/2-cycle), interrupting (5-cycle), and 30-cycle fault-current values for 3-phase, 2-phase, and phase-to-ground faults.
- F. Equipment Evaluation Report: Prepare a report on the adequacy of overcurrent protective devices and conductors by comparing fault-current ratings of these devices with calculated fault-current momentary and interrupting duties.

### 3.03 COORDINATION STUDY

- A. Gather and tabulate the following input data to support coordination study:
1. Product Data for overcurrent protective devices specified in other Division 16 Sections and 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.
  2. Impedance of utility service entrance.
  3. Electrical distribution system diagram showing the following:
    - a. Load current that is the basis for sizing continuous ratings of circuits for cables and equipment.
    - b. Circuit breaker and fuse-current ratings and types.
    - c. Relays and associated power and current transformer ratings and ratios.
    - d. Transformer kilovolt Amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.
    - e. Generator kilovolt Amperes, size, voltage, and source impedance.
    - f. Cables: Indicate conduit material, sizes of conductors, conductor insulation, and length.
    - g. Busway ampacity and impedance.
    - h. Motor horsepower and code letter designation according to NEMA MG 1.
  4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram:
    - a. Special load considerations, including starting inrush currents and frequent starting and stopping.
    - b. Magnetic inrush current overload capabilities of transformers.
    - c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
    - d. Ratings, types, and settings of utility company's overcurrent protective devices.
    - e. Special overcurrent protective device settings or types stipulated by utility company.
    - f. Time-current-characteristic curves of devices indicated to be coordinated.

- g. Manufacturer, frame size, interrupting rating in Amperes rms-symmetrical, Ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
  - h. Manufacturer and type, Ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
  - i. Panelboards, switchboards, motor control center ampacity, and interrupting rating in Amperes rms symmetrical.
- B. Perform coordination study and prepare a written report using the results of fault-current study and approved computer software program. Comply with IEEE 399.
- C. Comply with NFPA 70 for overcurrent protection of circuit elements and devices.
- D. Comply with IEEE 242 recommendations for fault currents and time intervals.
- E. Transformer Primary Overcurrent Protective Devices:
- 1. Device shall not operate in response to the following:
    - a. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
    - b. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
  - 2. Device shall protect transformer according to IEEE C57.12.00, for fault currents.
- F. Motors served by voltages more than 600 V shall be protected according to IEEE 620.
- G. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Verify adequacy of phase conductors at maximum three-phase bolted fault currents, equipment grounding conductors, and grounding electrode conductors at maximum ground-fault currents.
- H. Coordination-Study Report: Prepare a written report indicating the following results of coordination study:
- 1. Tabular Format of Settings Selected for Overcurrent Protective Devices:
    - a. Device tag.
    - b. Relay-current transformer ratios; tap, time-dial, and instantaneous-pickup values.
    - c. Circuit-breaker sensor rating and long-time, short-time, and instantaneous settings.
    - d. Fuse-current rating and type.
    - e. Ground-fault relay-pickup and time-delay settings.
  - 2. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between series devices, including power utility company's upstream devices. Show the following specific information:
    - a. Device tag.
    - b. Voltage and current ratio for curves.
    - c. Three-phase and single-phase damage points for each transformer.

- d. No damage, melting, and clearing curves for fuses.
- e. Cable damage curves.
- f. Transformer inrush points.
- g. Maximum fault-current cutoff point.

- 3. Completed data sheets for setting of overcurrent protective devices.

#### 3.04 OVERCURRENT PROTECTIVE DEVICE SETTING

- A. **Manufacturer's Field Service:** Engage a factory-authorized service representative of electrical distribution equipment being set and adjusted, to assist in the setting of overcurrent protective devices within equipment.
- B. **Testing:** Perform the following device setting and prepare reports:
  - 1. After installing overcurrent protective devices and during energizing process of electrical distribution system, perform the following:
    - a. Verify that overcurrent protective devices meet parameters used in studies.
    - b. Adjust devices to values listed in study results.
  - 2. Adjust devices according to recommendations in Chapter 7, "Inspection and Test Procedures," and Tables 10.7 and 10.8 in NETA ATS.

END OF SECTION 16055

SECTION 16060

GROUNDING AND BONDING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes grounding of electrical systems and equipment. Grounding requirements specified in this Section may be supplemented by special requirements of systems described in other Sections.

1.03 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Product Data: For the following:
  - 1. Ground rods.
- C. Qualification Data: For firms and persons specified in "Quality Assurance" Article.
- D. Field Test Reports: Submit written test reports to include the following:
  - 1. Test procedures used.
  - 2. Test results that comply with requirements.
  - 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.04 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Testing agency as defined by OSHA in 29 CFR 1910.7 or a member company of the International Electrical Testing Association and that is acceptable to authorities having jurisdiction.
  - 1. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association to supervise on-site testing specified in Part 3.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
  - 1. Comply with UL 467.
- C. Comply with NFPA 70; for overhead-line construction and medium voltage underground construction, comply with IEEE C2.
- D. Comply with NFPA 780 and UL 96 when interconnecting with existing lightning protection system.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Grounding Conductors, Cables, Connectors, and Rods:

- a. Apache Grounding/Erico Inc.
- b. Boggs, Inc.
- c. Chance/Hubbell.
- d. Copperweld Corp.
- e. Dossert Corp.
- f. Erico Inc.; Electrical Products Group.
- g. Framatome Connectors/Burndy Electrical.
- h. Galvan Industries, Inc.
- i. Harger Lightning Protection, Inc.
- j. Hastings Fiber Glass Products, Inc.
- k. Heary Brothers Lightning Protection Co.
- l. Ideal Industries, Inc.
- m. ILSCO.
- n. Kearney/Cooper Power Systems.
- o. Korns: C. C. Korns Co.; Division of Robroy Industries.
- p. Lightning Master Corp.
- q. Lyncole XIT Grounding.
- r. O-Z/Gedney Co.; a business of the EGS Electrical Group.
- s. Raco, Inc.; Division of Hubbell.
- t. Robbins Lightning, Inc.
- u. Salisbury: W. H. Salisbury & Co.
- v. Superior Grounding Systems, Inc.
- w. Thomas & Betts, Electrical.

2.02 GROUNDING CONDUCTORS

A. For insulated conductors, comply with Division 16 Section 16120, "Conduit and Cables."

B. Material: Aluminum, copper-clad aluminum, and copper.

C. Equipment Grounding Conductors: Insulated with green-colored insulation.

D. Grounding Electrode Conductors: Stranded cable.

E. Underground Conductors: Bare, tinned, stranded, unless otherwise indicated.

F. Bare Copper Conductors: Comply with the following:

1. Solid Conductors: ASTM B 3.
2. Assembly of Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.

G. Copper Bonding Conductors: As follows:

1. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG copper conductor, 1/4 inch in diameter.

2. Bonding Conductor: No. 4 or No. 6 AWG, stranded copper conductor.
3. Bonding Jumper: Bare copper tape, braided bare copper conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
4. Tinned Bonding Jumper: Tinned-copper tape, braided copper conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

H. Aluminum Bonding Conductors: As follows:

1. Bonding Cable: 10 strands of No. 14 AWG aluminum conductor, 1/4 inch in diameter.
2. Bonding Conductor: No. 4 or No. 6 AWG, stranded aluminum conductor.
3. Bonding Jumper: Aluminum tape, braided bare aluminum conductors, terminated with aluminum ferrules; 1-5/8 inches wide and 1/16 inch thick.

I. Ground Conductor and Conductor Protector for Wood Poles: As follows:

1. No. 4 AWG minimum, soft-drawn copper conductor.
2. Conductor Protector: Half-round PVC or wood molding. If wood, use pressure-treated fir, or cypress or cedar.

J. Grounding Bus: Bare, annealed copper bars of rectangular cross section, with insulators.

## 2.03 CONNECTOR PRODUCTS

- A. Comply with IEEE 837 and UL 467; listed for use for specific types, sizes, and combinations of conductors and connected items.
- B. Bolted Connectors: Bolted-pressure-type connectors, or compression type.
- C. Welded Connectors: Exothermic-welded types, in kit form, and selected per manufacturer's written instructions.

## 2.04 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel.
- B. Ground Rods: Sectional type; copper-clad steel.
  1. Size: 5/8 inches in diameter by 96" long, or as otherwise noted.

## PART 3 - EXECUTION

### 3.01 APPLICATION

- A. Use only copper conductors for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.
- B. In raceways, use insulated equipment grounding conductors.
- C. Exothermically-Welded Connections: Use for connections to structural steel and for underground connections, except those at test wells.
- D. Equipment Grounding Conductor Terminations: Use bolted pressure clamps.
- E. Grounding Bus: Install in electrical rooms, in rooms housing service equipment, and elsewhere as indicated.



1. Use insulated spacer; space 1 inch from wall and support from wall 6 inches above finished floor, unless otherwise indicated.
2. At doors, route the bus up to the top of the door frame, across the top of the doorway, and down to the specified height above the floor.

F. Underground Grounding Conductors: Use copper conductor, No. 2/0 AWG minimum. Bury at least 24 inches below grade or bury 12 inches above duct bank when installed as part of the duct bank.

### 3.02 EQUIPMENT GROUNDING CONDUCTORS

A. Comply with NFPA 70, Article 250, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by NFPA 70 are indicated.

B. Install equipment grounding conductors in all feeders and circuits.

C. Install insulated equipment grounding conductor with circuit conductors for the following items, in addition to those required by NEC:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Armored and metal-clad cable runs.

D. Busway Supply Circuits: Install insulated equipment grounding conductor from the grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.

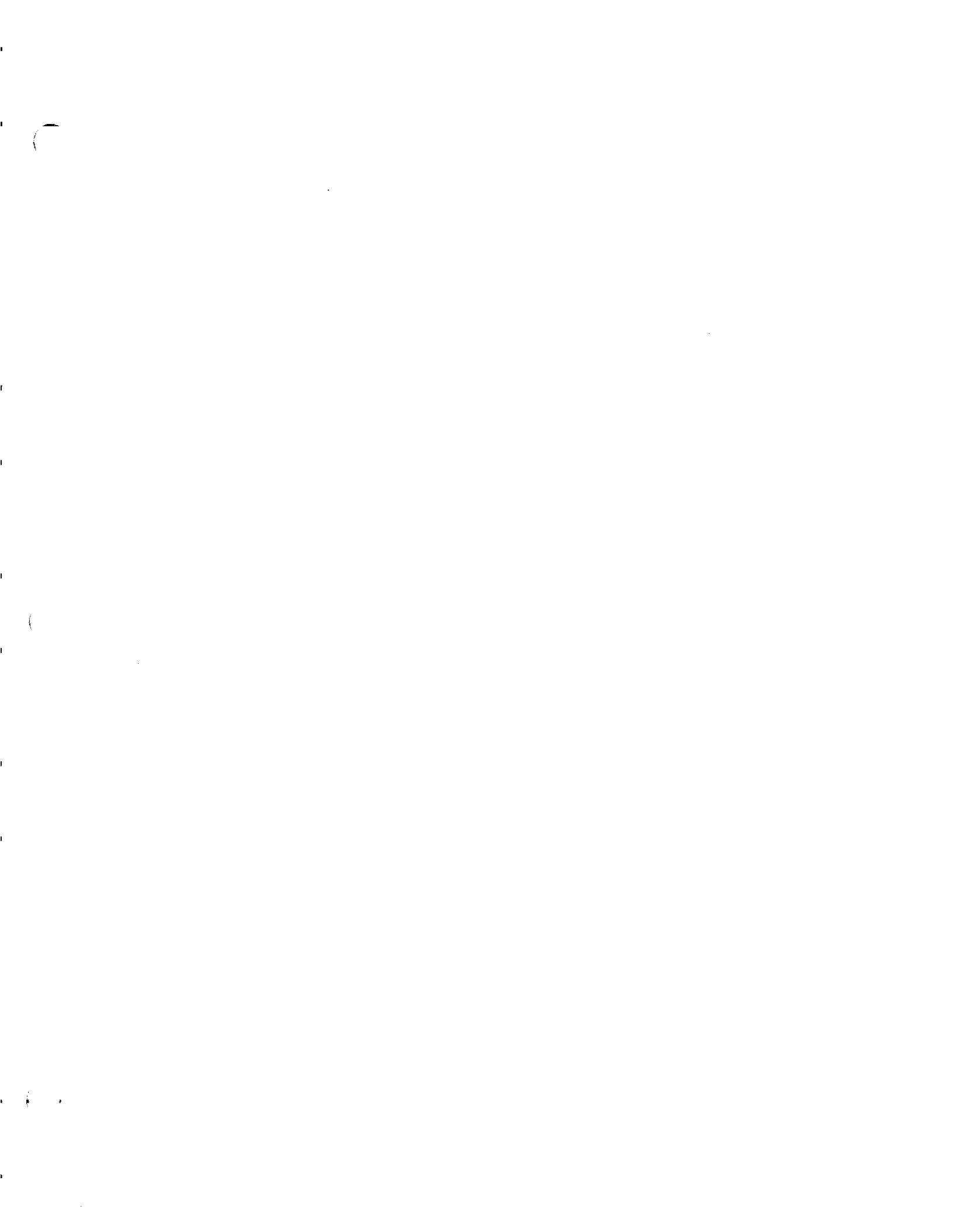
E. X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.

F. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate equipment grounding conductor. Isolate equipment grounding conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.

G. Nonmetallic Raceways: Install an equipment grounding conductor in nonmetallic raceways unless they are designated for telephone or data cables.

H. Air-Duct Equipment Circuits: Install an equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners and heaters. Bond conductor to each unit and to air duct.

I. Common Ground Bonding 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.



bus or terminal in housing. Bond electrically noncontinuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.

- E. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- F. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.
- G. Moisture Protection: If insulated grounding conductors are connected to ground rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

END OF SECTION 16060

SECTION 16072

ELECTRICAL SUPPORTS AND SEISMIC CONSIDERATIONS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following:
  - 1. Hangers and supports for electrical equipment and systems.
  - 2. Seismic restraints for electrical equipment and systems.
  - 3. Construction requirements for concrete bases.

1.03 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. IBC: International Building Code.
- C. IMC: Intermediate metal conduit.
- D. MI: Mineral-insulated cable.
- E. NBC: National Building Code.
- F. OSHPD: Office of Statewide Health Planning and Development.
- G. RMC: Rigid metal conduit.
- H. SBC: Standard Building Code.
- I. Seismic Restraint: A structural support element such as a metal framing member, a cable, an anchor bolt or stud, a fastening device, or an assembly of these items used to transmit seismic forces from an item of equipment or system to building structure and to limit movement of item during a seismic event.
- J. UBC: Uniform Building Code.

1.04 SUBMITTALS

- A. Product Data: Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of electrical support and seismic-restraint component used.
  - 1. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
  - 2. Annotate to indicate application of each product submitted and compliance with requirements.

- B. Shop Drawings: Indicate materials and dimensions and identify hardware, including attachment and anchorage devices, signed and sealed by a qualified professional engineer. Professional engineer qualification requirements are specified in Division 1 Section, "Quality Requirements." Include the following:
1. Fabricated Supports: Representations of field-fabricated supports not detailed on Drawings.
  2. Seismic Restraints: Detail anchorage and bracing not defined by details or charts on Drawings. Include the following:
    - a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
    - b. Details: Detail fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events.
    - c. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).
- C. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.
- D. Welding certificates.
- E. Qualification Data: For professional engineer and testing agency.
- F. Field quality-control test reports.

#### 1.05 QUALITY ASSURANCE

- A. Testing of Seismic Anchorage Devices: Comply with testing requirements in Part 3 and in Division 16 Section 16050, "Basic Electrical Methods."
- B. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

### PART 2 - PRODUCTS

#### 2.01 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
  1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

#### 2.02 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed under this Project, with a minimum structural safety factor of five times the applied force.

- B. Steel Slotted Support Systems: Comply with MFMA-3, factory-fabricated components for field assembly.
1. Manufacturers:
    - a. Cooper B-Line; a division of Cooper Industries.
    - b. ERICO International Corporation.
    - c. Allied Support Systems; Power-Strut Unit.
    - d. GS Metals Corp.
    - e. Michigan Hanger Co., Inc.; O-Strut Div.
    - f. National Pipe Hanger Corp.
    - g. Thomas & Betts Corporation.
    - h. Unistrut; Tyco International, Ltd.
    - i. Wesanco, Inc.
  2. Finishes:
    - a. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-3.
    - b. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-3.
    - c. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-3.
  3. Channel Dimensions: Selected for structural loading and applicable seismic forces.
- C. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16-inch diameter holes at a maximum of 8 inches o.c., in at least one surface.
1. Manufacturers:
    - a. Allied Support Systems; Aickinstrut Unit.
    - b. Cooper B-Line; a division of Cooper Industries.
    - c. Fabco Plastics Wholesale Limited.
    - d. Seasafe, Inc.
  2. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
  3. Fitting and Accessory Materials: Same as channels and angles
  4. Rated Strength: Selected to suit structural loading and applicable seismic forces.
- D. Raceway and Cable Supports: As described in NECA 1.
- E. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- F. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
- G. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

- H. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
    - a. Manufacturers:
      - 1) Hilti, Inc.
      - 2) ITW Construction Products.
      - 3) MKT Fastening, LLC.
      - 4) Simpson Strong-Tie Co. Inc.
  2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated or stainless steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
    - a. Manufacturers:
      - 1) Cooper B-Line; a division of Cooper Industries.
      - 2) Empire Tool and Manufacturing Co., Inc
      - 3) Hilti, Inc.
      - 4) ITW Construction Products.
      - 5) MKT Fastening, LLC.
      - 6) Powers Fasteners.
  3. Concrete Inserts: Steel or malleable-iron slotted-support-system units similar to MSS Type 18; complying with MFMA-3 or MSS SP-58.
  4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
  5. Through Bolts: Structural type, hex head, high strength. Comply with ASTM A 325.
  6. Toggle Bolts: All-steel springhead type.
  7. Hanger Rods: Threaded steel.

### 2.03 SEISMIC-RESTRAINT COMPONENTS

- A. Rated Strength, Features, and Application Requirements for Restraint Components: As defined in reports by an agency acceptable to authorities having jurisdiction.
1. Structural Safety Factor: Strength in tension, shear, and pullout force of components used shall be at least five times the maximum seismic forces to which they will be subjected.
- B. Angle and Channel-Type Brace Assemblies: Steel angles or steel slotted-support-system components; with accessories for attachment to braced component at one end and to building structure at the other end.
- C. Cable Restraints: ASTM A 603, zinc-coated, steel wire rope attached to steel or stainless-steel thimbles, brackets, swivels, and bolts designed for restraining cable service.
1. Manufacturers:
    - a. Amber/Booth Company, Inc.

- b. Loos & Co., Inc.
  - c. Mason Industries, Inc.
- 2. Seismic Mountings, Anchors, and Attachments: Devices as specified in Part 2 "Support, Anchorage, and Attachment Components" Article, selected to resist seismic forces.
  - 3. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or reinforcing steel angle clamped to hanger rod, of design recognized by an agency acceptable to authorities having jurisdiction.
  - 4. Bushings for Floor-Mounted Equipment Anchors: Neoprene units designed for seismically rated rigid equipment mountings, and matched to type and size of anchor bolts and studs used.
  - 5. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for seismically rated rigid equipment mountings, and matched to type and size of attachment devices used.

#### 2.04 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted, structural steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Division 5 Section, "Metal Fabrications" for steel shapes and plates.

### PART 3 - EXECUTION

#### 3.01 APPLICATION

- A. Comply with NECA 1 for application of hangers and supports for electrical equipment and systems, except if requirements in this Section are stricter.
- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.
- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
  - 1. Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.
  - 2. Secure raceways and cables to these supports with two-bolt conduit clamps, single-bolt conduit clamps, or single-bolt conduit clamps using spring friction action for retention in support channel.
- D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

#### 3.02 SUPPORT AND SEISMIC-RESTRAINT INSTALLATION

- A. Comply with NECA 1 for installation requirements, except as specified in this Article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, MI or RMC, may be supported by openings through structure members, as permitted in NFPA 70.



- C. Install seismic-restraint components using methods approved by the evaluation service providing required submittals for component.
- D. **Strength of Support and Seismic-Restraint Assemblies:** Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lbs.
- E. **Mounting and Anchorage of Surface-Mounted Equipment and Components:** Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
  - 1. To Wood: Fasten with lag screws or through bolts.
  - 2. To New Concrete: Bolt to concrete inserts.
  - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
  - 4. To Existing Concrete: Expansion anchor fasteners.
  - 5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
  - 6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts, beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69, or Spring-tension clamps.
  - 7. To Light Steel: Sheet metal screws.
  - 8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.
- F. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

### 3.03 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Division 5 Section, "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

### 3.04 CONCRETE BASES

- A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and seismic criteria at Project.
- B. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so expansion anchors will be a minimum of 10 bolt diameters from edge of the base.
  - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of the base.
  - 2. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.

3. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
6. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 3 Section, "Cast-in-Place Concrete."

### 3.05 INSTALLATION OF SEISMIC-RESTRAINT COMPONENTS

- A. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- B. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- C. Restraint Cables: Provide slack within maximums recommended by manufacturer.
- D. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, upper truss chords of bar joists, or at concrete members.

### 3.06 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- A. Make flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross expansion and seismic-control joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to electrical equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

### 3.07 FIELD QUALITY CONTROL

- A. Testing: Test pullout resistance of seismic anchorage devices.
  1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
  2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post-connection testing has been approved), and with at least seven days' advance notice.
  3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
  4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
  5. Test to 90 percent of rated proof load of device.
  6. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.
- B. Record test results.

END OF SECTION 16072

SECTION 16075

ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following:
  - 1. Identification for raceway and metal-clad cable.
  - 2. Identification for conductors and communication and control cable.
  - 3. Underground cable warning tape.
  - 4. Warning labels and signs.
  - 5. Instruction signs.
  - 6. Equipment identification labels.
  - 7. Miscellaneous identification products.

1.03 SUBMITTALS

- A. Product Data: For each electrical identification product indicated.
- B. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.
- C. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.

1.04 QUALITY ASSURANCE

- A. Comply with ANSI A13.1 and ANSI C2.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.145.

1.05 COORDINATION

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.
- B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- C. Coordinate installation of identifying devices with location of access panels and doors.
- D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.01 RACEWAY, MI AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
- B. Color for Printed Legend:
  - 1. Power Circuits: Black letters on an orange or yellow field.
  - 2. Legend: Indicate system or service and voltage, if applicable.
- C. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- D. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- E. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- F. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches wide; compounded for outdoor use.

2.02 CONDUCTOR AND COMMUNICATION- AND CONTROL-CABLE IDENTIFICATION MATERIALS

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.
- B. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
- C. Aluminum Wraparound Marker Labels: Cut from 0.014-inch thick aluminum sheet, with stamped, embossed, or scribed legend, and fitted with tabs and matching slots for permanently securing around wire or cable jacket or around groups of conductors.
- D. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inches, with stamped legend, punched for use with self-locking nylon tie fastener.
- E. Write-On Tags: Polyester tag, 0.015 inch thick, with corrosion-resistant grommet and polyester or nylon tie for attachment to conductor or cable.
  - 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

2.03 WARNING LABELS AND SIGNS

- A. Comply with NFPA 70 and 29 CFR 1910.145.

- B. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.
- C. Baked-Enamel Warning Signs: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 1/4-inch grommets in corners for mounting. Nominal size, 7 by 10 inches.
- D. Metal-Backed, Butyrate Warning Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for application. 1/4-inch grommets in corners for mounting. Nominal size, 10 by 14 inches.
- E. Warning label and sign shall include, but are not limited to, the following legends:
  - 1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
  - 2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."
- F. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch thick for signs up to 20 sq. in. and 1/8 inch thick for larger sizes.
  - 1. Engraved legend with black letters on white face.
  - 2. Punched or drilled for mechanical fasteners.
  - 3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

#### 2.04 EQUIPMENT IDENTIFICATION LABELS

- A. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch.
- B. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and ultraviolet-resistant seal for label.
- C. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch.
- D. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch.
- E. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.

#### 2.05 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.
  - 1. Minimum Width: 3/16 inch.
  - 2. Tensile Strength: 50 lb, minimum.
  - 3. Temperature Range: Minus 40 to plus 185 deg F.
  - 4. Color: Black, except where used for color-coding.

- B. Paint: Paint materials and application requirements are specified in Division 9 painting Sections.
1. Exterior Concrete, Stucco, and Masonry (Other Than Concrete Unit Masonry):
    - a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
      - 1) Primer: Exterior concrete and masonry primer.
      - 2) Finish Coats: Exterior semigloss acrylic enamel.
  2. Exterior Concrete Unit Masonry:
    - a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over block filler.
      - 1) Block Filler: Concrete unit masonry block filler.
      - 2) Finish Coats: Exterior semigloss acrylic enamel.
  3. Exterior Ferrous Metal:
    - a. Semigloss Alkyd-Enamel Finish: Two finish coat(s) over a primer.
      - 1) Primer: Exterior ferrous-metal primer.
      - 2) Finish Coats: Exterior semigloss alkyd enamel.
  4. Exterior Zinc-Coated Metal (except Raceways):
    - a. Semigloss Alkyd-Enamel Finish: Two finish coat(s) over a primer.
      - 1) Primer: Exterior zinc-coated metal primer.
      - 2) Finish Coats: Exterior semigloss alkyd enamel.
  5. Interior Concrete and Masonry (Other Than Concrete Unit Masonry):
    - a. Semigloss Alkyd-Enamel Finish: Two finish coat(s) over a primer.
      - 1) Primer: Interior concrete and masonry primer.
      - 2) Finish Coats: Interior semigloss alkyd enamel.
  6. Interior Concrete Unit Masonry:
    - a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a block filler.
      - 1) Block Filler: Concrete unit masonry block filler.
      - 2) Finish Coats: Interior semigloss acrylic enamel.
  7. Interior Gypsum Board:
    - a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
      - 1) Primer: Interior gypsum board primer.
      - 2) Finish Coats: Interior semigloss acrylic enamel.

8. Interior Ferrous Metal:
    - a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
      - 1) Primer: Interior ferrous-metal primer.
      - 2) Finish Coats: Interior semigloss acrylic enamel.
  9. Interior Zinc-Coated Metal (except Raceways):
    - a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
      - 1) Primer: Interior zinc-coated metal primer.
      - 2) Finish Coats: Interior semigloss acrylic enamel.
- C. Fasteners for Labels and Signs: Self-tapping, stainless steel screws or stainless steel machine screws with nuts and flat and lock washers.

### PART 3 - EXECUTION

#### 3.01 APPLICATION

- A. Raceways and Duct Banks Rated More Than 600 V Concealed within Buildings: 4-inch wide black stripes on 10-inch centers over orange background that extends full length of raceway or duct and is 12 inches wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch high black letters on 20-inch centers. Stop stripes at legends. Apply to the following finished surfaces:
  1. Floor surface directly above conduits running beneath and within 12 inches of a floor that is in contact with earth or is framed above unexcavated space.
  2. Wall surfaces directly external to raceways concealed within wall.
  3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.
- B. Accessible Raceways and Metal-Clad Cables, 600 V or less, for Service, Feeder, and Branch Circuits more than 30A: Identify with orange self-adhesive vinyl label, snap-around label, or self-adhesive vinyl tape applied in bands.
- C. Accessible Raceways Boxes and Fittings of Systems: Identify the following systems with color-coded, self-adhesive vinyl tape applied in bands or snap-around, color-coding bands, unless indicated to be painted:
  1. Emergency Power: Orange Paint (Boxes and Fittings).
  2. Fire Alarm System: Red Paint (Boxes and Fittings).
  3. Fire-Suppression Supervisory and Control System: Red and yellow.
  4. Combined Fire Alarm and Security System: Red and blue.
  5. Security System: Blue and yellow.
  6. Mechanical and Electrical Supervisory System: Green and blue.
  7. Telecommunication System: Green and yellow.
  8. Control Wiring: Green and red.
- D. Power-Circuit Conductor Identification: For primary and secondary conductors No. 1/0 AWG and larger in vaults, pull and junction boxes, manholes, and handholes use aluminum wraparound marker labels or metal tags. Identify source and circuit number of each set of conductors. For single conductor cables, identify phase in addition to the above.

- E. Branch-Circuit Conductor Identification: Where there are conductors for more than three branch circuits in same junction or pull box, use color-coding conductor tape, marker tape, aluminum wraparound marker labels or metal tags. Identify each ungrounded conductor according to source and circuit number.
- F. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source and circuit number.
- G. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.
  - 1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
  - 2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
  - 3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual.
- H. Locations of Underground Cables: Identify with underground cable warning tape for power, lighting, communication, and control wiring and optical fiber cable. Install underground-line warning tape for both direct-buried cables and cables in raceway.
- I. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply self-adhesive warning labels or metal-backed, butyrate warning signs. Identify system voltage with black letters on an orange or yellow background. Apply to exterior of door, cover, or other access.
  - 1. Equipment with Multiple Power or Control Sources: Apply to door or cover of equipment including, but not limited to, the following:
    - a. Power transfer switches.
    - b. Controls with external control power connections.
    - c. Generator synchronization systems.
  - 2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.
  - 3. Equipment requiring Arch Flash Hazard Warning Labels: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.
- J. Instruction Signs:
  - 1. Operating Instructions: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
  - 2. Emergency Operating Instructions: Install instruction signs with white legend on a red background with minimum 3/8-inch high letters for emergency instructions at equipment used for power transfer, synchronization, or load shedding.
- K. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power,



lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1. Labeling Instructions:

- a. Indoor Equipment: Adhesive film label with clear protective overlay; Self-adhesive, engraved, laminated acrylic or melamine label, or; Engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch high letters on 1-1/2-inch high label; where 2 lines of text are required, use labels 2 inches high.
- b. Outdoor Equipment: Engraved, laminated acrylic or melamine label 4 inches high.
- c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.

2. Equipment to Be Labeled:

- a. Panelboards, electrical cabinets, and enclosures.
- b. Access doors and panels for concealed electrical items.
- c. Electrical switchgear and switchboards.
- d. Transformers.
- e. Emergency system boxes and enclosures.
- f. Disconnect switches.
- g. Enclosed circuit breakers.
- h. Motor starters.
- i. Pushbutton stations.
- j. Power transfer equipment.
- k. Monitoring and control equipment.

3.02 INSTALLATION

- A. Verify identity of each item before installing identification products.
- B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- C. Apply identification devices to surfaces that require finish after completing finish work.
- D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- E. Attach non-adhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.
- F. System Identification Color Banding for Raceways and Cables: Each color band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- G. Color-Coding for Phase and Voltage Level Identification, 600 V and Less: Use the colors listed below for ungrounded feeder and branch circuit service, feeder, and conductors.

1. Colors for 208/120-V Circuits:

- a. Phase A: Black.
- b. Phase B: Red.

- c. Phase C: Blue.
- 2. Colors for 480/277-V Circuits:
  - a. Phase A: Brown.
  - b. Phase B: Orange.
  - c. Phase C: Yellow.
- 3. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
- H. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.
- I. Underground Cable Warning Tape: During backfilling of trenches install continuous underground cable warning tape directly above cable at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.
- J. Painted Identification: Prepare surface and apply paint according to Division 9 painting Sections.

END OF SECTION 16075

SECTION 16120  
CONDUIT AND CABLES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes building wires and cables and associated connectors, splices, and terminations for wiring systems rated 600 V and less.

1.03 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Qualification Data: For testing agency.
- C. Field Quality Control Test Reports: From a qualified testing and inspecting agency engaged by Contractor.

1.04 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Testing agency as defined by OSHA in 29 CFR 1910.7 or a member company of the International Electrical Testing Association and that is acceptable to authorities having jurisdiction.
  - 1. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NFPA 70.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2.02 CONDUCTORS AND CABLES

- A. Manufacturers:
  - 1. Alcan Aluminum Corporation; Alcan Cable Div.
  - 2. American Insulated Wire Corp.; a Leviton Company.

3. General Cable Corporation.
  4. Senator Wire & Cable Company.
  5. Southwire Company.
  6. Pyrotenax
- B. Refer to Part 3 "Conductor and Insulation Applications" Article for insulation type, cable construction, and ratings.
- C. Conductor Material: Copper complying with NEMA WC 5 or 7; solid conductor for No. 12 AWG and smaller, stranded for No. 10 AWG and larger.
- D. Conductor Insulation Types: Type MI, THW, THHN-THWN and XHHW complying with NEMA WC 5 or 7.
- E. Multiconductor Cable: Healthcare Facility Armored cable, Type HCF-AC; and Healthcare Facility Metal-clad cable, Type HFC-MC with ground wire.
- F. All low voltage cable shall be plenum rated.

### 2.03 CONNECTORS AND SPLICES

- A. Manufacturers:
1. AFC Cable Systems, Inc.
  2. AMP Incorporated/Tyco International.
  3. Hubbell/Anderson.
  4. O-Z/Gedney; EGS Electrical Group LLC.
  5. 3M Company; Electrical Products Division.
  6. Pyrotenax
- B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

## PART 3 - EXECUTION

### 3.01 CONDUCTOR AND INSULATION APPLICATIONS

- A. Service Entrance: Type XHHW, single conductors in raceway.
- B. Exposed Feeders: Type THHN-THWN, single conductors in raceway.
- C. Feeders Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.
- D. Feeders Concealed in Concrete, below Slabs-on-Grade, and in Crawlspace: Type THHN-THWN, single conductors in raceway.
- E. Exposed Branch Circuits, including in Crawlspace: Type THHN-THWN, single conductors in raceway; Healthcare Facility Armored cable, Type HCF-AC; Healthcare Facility Metal-clad cable, Type HFC-MC; mineral-insulated, Type MI.
- F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway; Healthcare Facility Armored cable, Type HCF-AC; Healthcare Facility Metal-clad cable, Type HFC-MC; mineral-insulated, Type MI.

- G. Branch Circuits Concealed in Concrete and below Slabs-on-Grade: Type THHN-THWN, single conductors in raceway.
- H. Fire Alarm Circuits: Type THHN-THWN, in raceway; Power-limited, fire-protective, signaling circuit cable.
- I. Class 1 Control Circuits: Type THHN-THWN, in raceway.
- J. Class 2 Control Circuits: Type THHN-THWN, in raceway.

### 3.02 INSTALLATION

- A. Conceal cables in finished walls, ceilings and floors, unless otherwise indicated.
- B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, which will not damage cables or raceway.
- D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- E. Support cables according to Division 16 Section 16050, "Basic Electrical Methods."
- F. Seal around cables penetrating fire-rated elements according to Division 7 Section, "Through-Penetration Firestop Systems."
- G. Identify and color-code conductors and cables according to Division 16 Sections 16050 "Basic Electrical Methods" and 16075, "Electrical Identification."

### 3.03 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
  - 1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

### 3.04 FIELD QUALITY CONTROL

- A. Testing: Engage a qualified testing agency to perform the following field quality-control testing:
- B. Testing: Perform the following field quality-control testing:
  - 1. After installing conductors and cables and before electrical circuitry has been energized, test for compliance with requirements.
  - 2. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.3.1. Certify compliance with test parameters.

C. Test Reports: Prepare a written report to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

END OF SECTION 16120

SECTION 16125  
MEDIUM-VOLTAGE CABLES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes cables and related splices, terminations, and accessories for medium-voltage electrical distribution systems.

1.03 DEFINITIONS

- A. NETA ATS: Acceptance Testing Specification.

1.04 SUBMITTALS

- A. Product Data: For each type of cable indicated. Include splices and terminations for cables and cable accessories.
- B. Samples: 16-inch lengths of each type of cable indicated.
- C. Qualification Data: For Installer.
- D. Material Certificates: For each cable and accessory type, signed by manufacturers.
- E. Source quality-control test reports.
- F. Field quality-control test reports.

1.05 QUALITY ASSURANCE

- A. Installer: Engage a cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium-voltage cable.
- B. Source Limitations: Obtain cables and accessories through one source from a single manufacturer.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with IEEE C2 and NFPA 70.

1.06 PROJECT CONDITIONS

- A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
1. Notify Construction Manager and Owner no fewer than two days in advance of proposed interruption of electric service.
  2. Do not proceed with interruption of electric service without Construction Manager's written permission.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cables:
    - a. Kerite Co. (The); Hubbell Incorporated.
    - b. Okonite Company (The).
  2. Cable Splicing and Terminating Products and Accessories:
    - a. Engineered Products Company.
    - b. G&W Electric Company.
    - c. MPHusky.
    - d. Raychem Corp.; Telephone Energy and Industrial Division; Tyco International Ltd.
    - e. RTE Components; Cooper Power Systems, Inc.
    - f. Scott Fetzer Co. (The); Adalet.
    - g. Thomas & Betts Corporation.
    - h. Thomas & Betts Corporation/Elastimold.
    - i. 3M; Electrical Products Division.

2.02 CABLES

- A. Cable Type: MV105.
- B. Comply with UL 1072, AEIC CS 8, ICEA S-97-682.
- C. Conductor: Copper.
- D. Conductor Stranding: Compact round, concentric lay, Class B.
- E. Strand Filling: Conductor interstices are filled with impermeable compound.
- F. Conductor Insulation: Ethylene-propylene rubber.
1. Voltage Rating: 15 kV.
  2. Insulation Thickness: 133 percent insulation level.
- G. Shielding: Copper tape, helically applied over semiconducting insulation shield.
- H. Cable Jacket: Sunlight-resistant PVC.



2.03 SPLICE KITS

- A. Connectors and Splice Kits: Comply with IEEE 404; type as recommended by cable or splicing kit manufacturer for the application.
- B. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, ratings, and configurations of cable conductors. Include all components required for complete splice, with detailed instructions.
  - 1. Heat-shrink splicing kit of uniform, cross-section, polymeric construction with outer heat-shrink jacket. For indoor or manhole use as required with grounding accessory kit, in accordance with the characteristics of the cable furnished.
  - 2. Apply shielding tape to splices in shielded cables to continue shielded through entire splice.

2.04 SOLID TERMINATIONS

- A. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class is 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. Class 1 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, compression-type connector, and end seal.
  - 3. Class 2 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, and compression-type connector. Include silicone-rubber tape, cold-shrink-rubber sleeve, or heat-shrink plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.
  - 4. Class 3 Terminations: Kit with stress cone and compression-type connector.

2.05 SEPARABLE INSULATED CONNECTORS

- A. Description: Modular system, complying with IEEE 386, 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. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.
- C. 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.
- D. Dead-Break Cable Terminators: Elbow-type unit with 600-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 point on terminator body that is capacitance coupled.
- E. 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.

F. 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.

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

#### 2.06 ARC-PROOFING MATERIALS

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

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

C. Glass-Cloth Tape: Pressure-sensitive adhesive type, 1/2 inch wide.

#### 2.07 SOURCE QUALITY CONTROL

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.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

A. Install cables according to IEEE 576.

B. 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 will not deteriorate conductor or insulation.

2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips that will not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.

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

D. Install cable splices at pull points; use standard kits.

E. Install terminations at ends of conductors with standard kits.

- F. 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: Three.
  3. Standoff Insulator: Three.
- G. 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 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 1-inch- wide bands of half-lapped, adhesive, glass-cloth tape 2 inches o.c.
- H. Seal around cables passing through fire-rated elements.
- I. 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.
- J. Identify cables according to Division 16 Section "Electrical Identification."

### 3.02 FIELD QUALITY CONTROL

- A. Testing: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
- B. Perform the following field tests and inspections and prepare test reports:
1. Perform each visual and mechanical inspection and 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.
- C. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 16125

SECTION 16130  
RACEWAYS AND BOXES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.
- B. Related Sections include the following:
  - 1. Division 2 Section, "Underground Ducts and Utility Structures" for exterior ductbanks, manholes, and underground utility construction.
  - 2. Division 7 Section, "Through-Penetration Firestop Systems" for firestopping materials and installation at penetrations through walls, ceilings, and other fire-rated elements.
  - 3. Division 16 Section 16050, "Basic Electrical Methods" for supports, anchors, and identification products.
  - 4. Division 16 Section 16140, "Wiring Devices" for devices installed in boxes and for floor-box service fittings.

1.03 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. ENT: Electrical nonmetallic tubing.
- C. FMC: Flexible metal conduit.
- D. IMC: Intermediate metal conduit.
- E. LFMC: Liquidtight flexible metal conduit.
- F. LFNC: Liquidtight flexible nonmetallic conduit.
- G. MI: Mineral-insulated cable.
- H. RNC: Rigid nonmetallic conduit.

1.04 SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: Show fabrication and installation details of components for raceways, fittings, boxes, enclosures, and cabinets.
- C. Shop Drawings: Signed and sealed by a qualified professional engineer.
  - 1. Design Calculations: Calculate requirements for selecting seismic restraints.

2. Detail assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
- D. Coordination Drawings: Reflected ceiling plans drawn to scale and coordinating penetrations and ceiling-mounted items. Show the following:
1. Ceiling suspension assembly members.
  2. Method of attaching hangers to building structure.
  3. Size and location of initial access modules for acoustical tile.
  4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
- E. Manufacturer Seismic Qualification Certification: Submit certification that enclosures, cabinets, accessories, and components will withstand seismic forces defined in Division 16 Section 16072, "Electrical Supports and Seismic Considerations." Include the following:
1. Basis for Certification: Indicate whether the withstand certification is based on actual test of assembled components or on calculations.
    - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
  2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

#### 1.05 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.

#### 1.06 COORDINATION

- A. Coordinate layout and installation of raceways, boxes, enclosures, cabinets, and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

### PART 2 - PRODUCTS

#### 2.01 MANUFACTURERS

- A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
  1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

#### 2.02 METAL CONDUIT AND TUBING

- A. Manufacturers:
  1. AFC Cable Systems, Inc.

2. Alflec Inc.
  3. Anamet Electrical, Inc.; Anaconda Metal Hose.
  4. Electri-Flex Co.
  5. Grinnell Co./Tyco International; Allied Tube and Conduit Div.
  6. LTV Steel Tubular Products Company.
  7. Manhattan/CDT/Cole-Flex.
  8. O-Z Gedney; Unit of General Signal.
  9. Wheatland Tube Co.
  10. RobRoy
- B. Rigid Steel Conduit: ANSI C80.1.
- C. Aluminum Rigid Conduit: ANSI C80.5.
- D. IMC: ANSI C80.6.
- E. Plastic-Coated Steel Conduit and Fittings: NEMA RN 1.
- F. Plastic-Coated IMC and Fittings: NEMA RN 1.
- G. EMT and Fittings: ANSI C80.3.
1. Fittings: Setscrew or compression type.
- H. FMC: Zinc-coated steel.
- I. LFMC: Flexible steel conduit with PVC jacket.
- J. Fittings: NEMA FB 1; compatible with conduit and tubing materials.

## 2.03 NONMETALLIC CONDUIT AND TUBING

### A. Manufacturers:

1. American International.
  2. Anamet Electrical, Inc.; Anaconda Metal Hose.
  3. Arnco Corp.
  4. Cantex Inc.
  5. Certainteed Corp.; Pipe & Plastics Group.
  6. Condux International.
  7. ElecSYS, Inc.
  8. Electri-Flex Co.
  9. Lamson & Sessions; Carlon Electrical Products.
  10. Manhattan/CDT/Cole-Flex.
  11. RACO; Division of Hubbell, Inc.
  12. Spiralduct, Inc./AFC Cable Systems, Inc.
  13. Thomas & Betts Corporation.
- B. ENT: NEMA TC 13.
- C. RNC: NEMA TC 2, Schedule 40 and Schedule 80 PVC.
- D. ENT and RNC Fittings: NEMA TC 3; match to conduit or tubing type and material.
- E. LFNC: UL 1660.

2.04 METAL WIREWAYS

A. Manufacturers:

1. Hoffman.
2. Square D.

B. Material and Construction: Sheet metal sized and shaped as indicated, NEMA 1 or 3R, as indicated.

C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Select features, unless otherwise indicated, as required to complete wiring system and to comply with NFPA 70.

E. Wireway Covers: Hinged type, Screw-cover type, Flanged-and-gasketed type or as indicated.

F. Finish: Manufacturer's standard enamel finish.

2.05 NONMETALLIC WIREWAYS

A. Manufacturers:

1. Hoffman.
2. Lamson & Sessions; Carlon Electrical Products.

B. Description: Fiberglass polyester, extruded and fabricated to size and shape indicated, with no holes or knockouts. Cover is gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections are flanged, with stainless steel screws and oil-resistant gaskets.

C. Description: PVC plastic, extruded and fabricated to size and shape indicated, with snap-on cover and mechanically coupled connections with plastic fasteners.

D. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

E. Select features, unless otherwise indicated, as required to complete wiring system and to comply with NFPA 70.

2.06 SURFACE RACEWAYS

A. Surface Metal Raceways: Galvanized steel with snap-on covers. Finish with manufacturer's standard prime coating.

1. Manufacturers:

- a. Airey-Thompson Sentinel Lighting; Wiremold Company (The).
- b. Thomas & Betts Corporation.
- c. Walker Systems, Inc.; Wiremold Company (The).
- d. Wiremold Company (The); Electrical Sales Division.

- B. Surface Nonmetallic Raceways: Two-piece construction, manufactured of rigid PVC compound with matte texture and manufacturer's standard color.
1. Manufacturers:
    - a. Butler Manufacturing Co.; Walker Division.
    - b. Enduro Composite Systems.
    - c. Hubbell, Inc.; Wiring Device Division.
    - d. Lamson & Sessions; Carlon Electrical Products.
    - e. Panduit Corp.
    - f. Walker Systems, Inc.; Wiremold Company (The).
    - g. Wiremold Company (The); Electrical Sales Division.
- C. Types, sizes, and channels as indicated and required for each application, with fittings that match and mate with raceways.
- 2.07 BOXES, ENCLOSURES, AND CABINETS

A. Manufacturers:

1. Cooper/Crouse-Hinds; Div. of Cooper Industries, Inc.
  2. Emerson/General Signal; Appleton Electric Company.
  3. Erickson Electrical Equipment Co.
  4. Hoffman.
  5. Hubbell, Inc.; Killark Electric Manufacturing Co.
  6. O-Z/Gedney; Unit of General Signal.
  7. RACO; Division of Hubbell, Inc.
  8. Robroy Industries, Inc.; Enclosure Division.
  9. Scott Fetzer Co.; Adalet-PLM Division.
  10. Spring City Electrical Manufacturing Co.
  11. Thomas & Betts Corporation.
  12. Walker Systems, Inc.; Wiremold Company (The).
  13. Woodhead, Daniel Company; Woodhead Industries, Inc. Subsidiary.
- B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.
- C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, Type FD, with gasketed cover.
- D. Nonmetallic Outlet and Device Boxes: NEMA OS 2.
- E. Floor Boxes: Cast metal, fully adjustable, rectangular.
- F. Floor Boxes: Nonmetallic, nonadjustable, round.
- G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- H. Cast-Metal Pull and Junction Boxes: NEMA FB 1, cast aluminum with gasketed cover.
- I. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous hinge cover and flush latch.
1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
  2. Nonmetallic Enclosures: Plastic, finished inside with radio-frequency-resistant paint.



- J. Cabinets: NEMA 250, Type 1, galvanized steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel. Hinged door in front cover with flush latch and concealed hinge. Key latch to match panelboards. Include metal barriers to separate wiring of different systems and voltage and include accessory feet where required for freestanding equipment.

## 2.08 FACTORY FINISHES

- A. Finish: For raceway, enclosure, or cabinet components, provide manufacturer's standard prime-coat finish ready for field painting.
- B. Finish: For raceway, enclosure, or cabinet components, provide manufacturer's standard paint applied to factory-assembled surface raceways, enclosures, and cabinets before shipping.

## PART 3 - EXECUTION

### 3.01 RACEWAY APPLICATION

- A. Outdoors:
1. Exposed: Rigid steel.
  2. Concealed: Rigid steel.
  3. Underground, Single Run: RNC.
  4. Underground, Grouped: RNC.
  5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
  6. Boxes and Enclosures: NEMA 250, Type 3R or 4, or as otherwise indicated.
- B. Indoors:
1. Exposed: EMT unless noted otherwise on Drawings.
  2. Concealed: EMT unless noted otherwise on Drawings.
  3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC; except use LFMC in damp or wet locations.
  4. Damp or Wet Locations: Rigid steel conduit.
  5. Boxes and Enclosures: NEMA 250, Type 1, except as follows:
    - a. Damp or Wet Locations: NEMA 250, Type 4, stainless steel or nonmetallic.
- C. Minimum Raceway Size: 3/4-inch trade size.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
  2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings approved for use with that material. Patch all nicks and scrapes in PVC coating after installing conduits.
- E. Install nonferrous conduit or tubing for circuits operating above 60 Hz.
- F. Do not install aluminum conduits embedded in, or in contact with, concrete.

3.02 INSTALLATION

- A. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- B. Complete raceway installation before starting conductor installation.
- C. Support raceways as specified in Division 16 Section 16050, "Basic Electrical Methods."
- D. Install temporary closures to prevent foreign matter from entering raceways.
- E. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portions of bends are not visible above the finished slab.
- F. Make bends and offsets so ID is not reduced. Keep legs of bends in the same plane and keep straight legs of offsets parallel, unless otherwise indicated.
- G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.
  - 1. Install concealed raceways with a minimum of bends in the shortest practical distance, considering type of building construction and obstructions, unless otherwise indicated.
- H. Raceways Embedded in Slabs: Install in middle 1/3 of slab thickness where practical and leave at least 2 inches of concrete cover.
  - 1. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement.
  - 2. Space raceways laterally to prevent voids in concrete.
  - 3. Run conduit larger than 1-inch trade size parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
  - 4. Change from nonmetallic tubing to Schedule 80 nonmetallic conduit, rigid steel conduit, or IMC before rising above the floor.
- I. Install exposed raceways parallel or at right angles to nearby surfaces or structural members and follow surface contours as much as possible.
  - 1. Run parallel or banked raceways together on common supports.
  - 2. Make parallel bends in parallel or banked runs. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for parallel raceways.
- J. Join raceways with fittings designed and approved for that purpose and make joints tight.
  - 1. Use insulating bushings to protect conductors.
- K. Tighten setscrews of threadless fittings with suitable tools.
- L. Terminations:
  - 1. Where raceways are terminated with locknuts and bushings, align raceways to enter squarely and install locknuts with dished part against box. Use two locknuts, one inside and one outside box.
  - 2. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into hub so end bears against wire protection shoulder. Where chase nipples are used, align raceways so coupling is square to box; tighten chase nipple so no threads are exposed.

- M. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.
- N. Telephone and Signal System Raceways, 2-Inch trade size and smaller: In addition to above requirements, install raceways in maximum lengths of 150 feet and with a maximum of two 90-degree bends or equivalent. Separate lengths with pull or junction boxes where necessary to comply with these requirements.
- O. Install raceway-sealing fittings at suitable, approved, and accessible locations and fill them with UL-listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
  - 1. Conduits passing from warm to cold locations, such as boundaries of refrigerated spaces.
  - 2. Where otherwise required by NFPA 70.
- P. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment. Install with an adjustable top or coupling threaded inside for plugs set flush with finished floor. Extend conductors to equipment with rigid steel conduit; FMC may be used 6 inches above the floor. Install screwdriver-operated, threaded plugs flush with floor for future equipment connections.
- Q. Flexible Connections: Use maximum of 72 inches of flexible conduit for recessed and semi-recessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for all motors. Use LFMC in damp or wet locations. Install separate ground conductor across flexible connections.
- R. Surface Raceways: Install a separate, green, ground conductor in raceways from junction box supplying raceways to receptacle or fixture ground terminals.
- S. Install hinged-cover enclosures and cabinets plumb. Support at each corner.

### 3.03 PROTECTION

- A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
  - 1. Repair damage to galvanized finish with zinc-rich paint recommended by manufacturer.
  - 2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

### 3.04 CLEANING

- A. After completing installation of exposed, factory-finished raceways and boxes, inspect exposed finishes and repair damaged finishes.

END OF SECTION 16130

SECTION 16140  
WIRING DEVICES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following:
  - 1. Single and duplex receptacles, ground fault circuit interrupters.
  - 2. Single- and double-pole snap switches.
  - 3. Device wall plates.

1.03 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground fault circuit interrupter.
- C. PVC: Polyvinyl chloride.
- D. RFI: Radio-frequency interference.
- E. STP: Shielded twisted pair.
- F. TVSS: Transient voltage surge suppressor.
- G. UTP: Unshielded twisted pair.

1.04 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
- C. Samples: One for each type of device and wall plate specified, in each color specified.
- D. Field quality-control test reports.

1.05 QUALITY ASSURANCE

- A. Source Limitations: Obtain each type of wiring device through one source from a single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

- C. Comply with NFPA 70.

## PART 2 - PRODUCTS

### 2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Wiring Devices:
    - a. Hubbell Incorporated; Wiring Device-Kellems.
    - b. Pass & Seymour/Legrand; Wiring Devices Div.
  2. Multioutlet Assemblies:
    - a. Hubbell Incorporated; Wiring Device-Kellems.
    - b. Wiremold Company (The).
  3. Poke-Through, Floor Service Outlets:
    - a. Hubbell Incorporated; Wiring Device-Kellems.
    - b. Pass & Seymour/Legrand; Wiring Devices Div.
    - c. Wiremold Company (The).

### 2.02 RECEPTACLES

- A. Straight-Blade-Type Receptacles: Comply with NEMA WD 1, NEMA WD 6, DSCC W-C-596G, and UL 498.
- B. Locking Receptacles: Heavy, general duty grade.
- C. Straight-Blade Receptacles: Hospital grade.
- D. GFCI Receptacles: Straight blade, feed-through type, Hospital grade, with integral NEMA WD 6, Configuration 5-20R duplex receptacle; complying with UL 498 and UL 943. Design units for installation in a 2-3/4-inch deep outlet box without an adapter.

### 2.03 SWITCHES

- A. Single- and Double-Pole Switches: Comply with DSCC W-C-896F and UL 20.
- B. Snap Switches: Heavy or General-Duty grade, quiet type, as indicated.

### 2.04 WALL PLATES

- A. Single and combination types to match corresponding wiring devices.
1. Plate-Securing Screws: Metal with head to match plate finish.
  2. Material for Finished Spaces: Stainless steel.
  3. Material for Unfinished Spaces: Stainless steel.
  4. Material for Wet Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in "wet locations."

### 2.05 FINISHES

- A. Color:
1. Wiring Devices Connected to Normal Power System: Ivory.

2. Wiring Devices Connected to Emergency Power System: Red.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install devices and assemblies level, plumb, and square with building lines.
- B. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' written instructions.
- C. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical, and with grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.
- D. Remove wall plates and protect devices and assemblies during painting.
- E. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.02 IDENTIFICATION

- A. Comply with Division 16 Sections 16050, "Basic Electrical Methods" and 16075, "Electrical Identification."
  - 1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.
  - 2. Switches: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.03 CONNECTIONS

- A. Ground equipment according to Division 16 Section 16060, "Grounding and Bonding."
- B. Connect wiring according to Division 16 Section 16120, "Conduit and Cables."
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.04 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
  - 1. After installing wiring devices and after electrical circuitry has been energized, test for proper polarity, ground continuity, and compliance with requirements.
  - 2. Test GFCI operation with both local and remote fault simulations according to manufacturer's written instructions.
- B. Remove malfunctioning units, replace with new units, and retest as specified above.

END OF SECTION 16140

SECTION 16215

POWER MONITORING AND CONTROL SYSTEM

PART 1 - GENERAL

1.01 SYSTEM DESCRIPTION

- A. Furnish and install a complete Power Monitoring and Control System (PMCS) as detailed on the drawings and as described in this specification. The system is defined to include, but not be limited to, remote devices for monitoring, control and protection, device communication interface hardware, inter-communication wiring, personal computer workstations, software, printer where specified, and ancillary equipment.
- B. The manufacturer shall demonstrate the system is not a prototype and that similar systems have been field installed and successfully operated for at least five years. The PMCS vendor shall have full responsibility for insuring that the PMCS system performs as specified.
- C. The PMCS shall utilize Ethernet as the high-speed backbone network that supports direct connection of an unlimited number of personal computer workstations anywhere on the network.
- D. Each Personal Computer Workstation (PCW) connected to the network shall have web based access to information provided by the PMCS.
- E. The high-speed network shall allow direct access to data provided by the power monitoring devices for implementing automatic control.
- F. Application software for personal computer workstations shall be provided as described in Article 2.11 of this specification.
- G. The PMCS shall be POWERLOGIC as manufactured by Square D Company [or approved equal].
- H. All products shall not violate any U. S. patents.

1.02 REFERENCES

- A. The system shall comply with the applicable portions of NEMA standards. In addition, the control unit shall comply with FCC Emission Standards specified in Part 15, Sub-part J for Class A application.

1.03 SUBMITTALS

- A. PMCS Drawings: Drawings shall show all field monitoring devices, key networking components, and cabling required to complete the system. Drawings shall identify network connections and protocols. Drawings shall identify device room location and recommended installation notations. Specific locations and mounting details are subject to the discretion and responsibilities of the installation Contractor.
- B. Product Data: Provide catalog sheets and technical data sheets to indicate physical data and electrical performance, electrical characteristics, and connection requirements of each device supplied under the PMCS scope of work.

1.04 QUALITY

- A. The PMCS vendor shall be ISO 9000 registered to demonstrate quality compliance.
- B. PMCS components included within the power equipment lineups shall be factory installed, wired and tested prior to shipment to the job site.

1.05 RELATED SECTIONS

- A. Switchgear – Specification 16341

PART 2 - PRODUCT

2.01 PMCS APPLICATION SOFTWARE

A. General

1. The PMCS software vendor shall be capable of furnishing application software as identified in Section 2 for this project.
2. The PMCS shall include with user-friendly software suitable for operation on a computer workstation and shall be available for all computers included on the network.
3. The software shall be developed by the manufacturer of the monitoring devices, and shall be designed specifically for energy, power monitoring and control.
4. The software shall be configured, not programmed. All software shall be configured by the vendor and delivered ready to use. This configuration shall include preparation of all graphics, displays, and interactive one-line diagrams required as a part of this project.
5. Configuration shall be to the point that when additional monitoring devices are added, the user shall only need to convey to the software the communications address and type of the new device. The software shall then be able to display all data from that device in a format identical to that used for other devices of the same type.
6. The software shall be a standard product offering with no customization required.
7. Clients shall interface with the Server PCW (Personal Computer Workstation) via Internet Explorer browser, no additional software application install shall be required for Client communication with Server PCW.
8. Browser based clients shall access server through standard ASP (active server page) interface that is capable of displaying:
  - a. Historical Reports that can be customized and saved to users PC.
  - b. Graphical displays with real-time data updates
  - c. Real-time data and trend displays via TCP connection to monitoring devices.
  - d. Electronic documentation (support of .pdf, .doc, .txt, .html, .htm, .xls, .ppt).
  - e. Setup of client based display preferences.
9. Web links shall be available in an HTML file.
10. Web-enabled software shall support the viewing of interactive graphics in a browser client.
11. The software shall be supported by the manufacturer through regular maintenance upgrades, which are available for download from the web via annual support agreements.
12. The manufacturer shall make available regularly scheduled training classes to provide instruction to the user on the operation of the software.
13. The software vendor shall offer a Technical Support program to offer technical assistance on using the software and associated monitoring devices to manage the PMCS. The vendor shall have the ability to connect remotely to the PMCS to troubleshoot and diagnose any problems.
14. Software shall support the following communications and protocols:
  - a. Modbus TCP/IP (Ethernet)



- b. Serial Modbus RTU
  - c. Symax (RS485 and RS232 two wire or four wire)
  - d. OPC Server
  - e. JBUS
15. Device setup shall be accessible in both on-line and off-line modes.
16. Administration functions shall permit on-line system & device setup including configuration of data, alarm and waveform logs. Shall allow the user to define alarms and configure relay operation.
17. Administration functions shall allow devices and quantities to be organized into logical groups (function, location, department, etc.). Groups shall be user defined, each group having a unique name.
18. Shall include an on-line, context sensitive help system.
19. Alarms/Events shall be recorded in both an Active Alarm and in Alarm Log view.
20. Alarm Log shall be capable of holding at least 1000 events. The number of viewable events shall be user defined and only limited by size of storage drive.
21. The Alarm Log shall record date/time of the event, event description, and user name (if applicable).
22. The Alarm log shall provide an indication of and link to all waveform capture views associated to an event.
23. The Alarm Log shall record occurrences that are related to the operation of the software such as breakers opening, or closing, loss of power, loss of device communications, user logon, changes to system setup, etc.
24. Shall monitor for real-time alarm conditions detected by each device and provide alarm indication.
- a. Ten severity levels shall be supported for analog and digital alarm conditions, each level shall provide user audible, visible, and/or required acknowledgment. Severity levels can be customized changing color and/or sounds all password protected
  - b. Alarms shall be reported by exception.
  - c. Alarms shall be on-board or PC-based and a summary of all active alarms may be viewed at any time.
25. Shall display the status of digital I/O status.
26. Shall provide real time, user friendly tabular displays of electric plant information.
27. Shall provide equipment ratings documenting
28. Shall provide the capability to report sums, differences, and percentages of real-time readings for multiple devices . This data shall be available for real-time reporting, logging and trending, and alarm functions.
29. Shall log PMCS data to the PC hard disk on demand or at user specified intervals
30. PMCS Standard Reporting shall include:
- a. Standard report templates that include: History tables and trends, Power Factor, Harmonics, Cost Allocation, Energy Consumption and Alarm Analysis. Program shall also allow for custom report creation.
  - b. Report creation tool shall be Wizard driven.
  - c. Report presentation shall be available in a number of graphics formats such as: Trends, Tables, Histograms or Pareto Charts, Pie Charts. Graphics shall be customizable by changing colors, text, headings, size, graphic plot styles (bar graphs, line graphs, etc).
  - d. Statistics on trending data for devices in the PMCS system which includes minimum and maximum values and their associated date and time stamps, average value, standard deviation and load factor.
  - e. Shall be available in a customizable HTML format.
  - f. Shall have the ability to Email reports.

- g. Be able to generate either on demand or as a scheduled task to run automatically at specified intervals from the server via administration functions.
  - h. Shall have a quick reporting function to allow user to generate information quickly without having to define calculations, quantities and outputs.
  - i. Shall have the ability to view data from different devices on the same trend plot simultaneously.
  - j. Shall have the ability to e-mail report via automated e-mail task.
31. Software shall notify user of available logged data and its date range to run reports on.
32. Shall retrieve and display data and alarm and event logs created and stored in circuit monitors.
33. The PMCS shall capture (either on demand or on alarm/event), log, and present graphically the following waveforms and harmonic information based on user specified criteria.
- a. Provide graphical waveform displays for the phase voltages, phase currents, and residual current monitored by circuit monitors. Additional displays shall include overlay of 3 phases of voltage, overlay of 3 phases of current, and each phase voltage and current overlaid.
  - b. Shall setup, retrieve, display, and store multiple waveform types up to 1320 seconds in length and/or cycle by cycle formats from circuit monitors.
  - c. Provide the ability to record and display waveforms:
  - d. Shall provide the capability to associate and link Disturbance Waveform Captures to Transient Waveform captures in the same display/view.
  - e. Provide the ability to view cycle by cycle and 100ms recording
  - f. Shall have pre-event WFC data capabilities.
  - g. Shall be able to provide FFT, RMS and Spectrum Waveform analysis views.
  - h. Provide the ability to zoom in/out of waveform.
  - i. Shall support IEC Comtrade format.
  - j. Shall be capable of translating WFC data to PQDif format.
34. Shall allow Dynamic Data Exchange (DDE).
- a. Shall serve system data to other applications supporting DDE for advanced reporting and graphics.
  - b. Shall read, display, log, trend, and alarm DDE data from other applications.
  - c. Shall allow the creation of custom quantities to read DDE quantities from other applications and metered values from other utilities (gas, water, steam , and air pressure).
35. Shall comply with the Open Database Connectivity (ODBC) standards of data storage to allow other software products easy access to the stored information. Shall be possible to format data stored by the server for any ODBC database.
36. Shall provide an integrated tool that allows user to:
- a. Configure, set and schedule full system database backups to desired storage media
  - b. Configure and schedule historical archive parameters.
37. Shall be capable of password-protected control of system operations from the PC including the operation of Circuit monitor outputs, PLC outputs, electronic trip units, digital protective relays, and other devices.
- a. Set up and control functions shall be password protected. Passwords will be case sensitive.

39. Shall allow user to create custom tables for viewing electric system information in convenient formats. Custom tables shall be easily modified as need arises.

B. Software Requirements

1. The PMCS software vendor shall provide a Professional Edition software solution for enterprise wide PMCS applications with unlimited device connections.
2. The PMCS software vendor shall provide a Standard Edition software solution that is scalable dependent upon the number of device connections for the specific project application. **Standard Edition**
3. The Personal Computer Workstation (PCW) equipped with the PMCS (recommended operating requirements):
  - a. Microsoft Windows 2003 Standard Server (32-bit), Windows 2003 Enterprise Server (32-bit) & Windows XP Professional (32-bit) operating systems. Internet Explorer v6.0 SP1 or higher, Windows Script Hosting version 5.6 or higher, Windows Message Queuing, Windows Internet Information Services (IIS) v5.0 or higher, 1.2 GHz P-III processor, 512 MB SDRAM, 20 GB IDE HD's, DVD-ROM Drive, 56k PCI, machine can be Tower or Rack Mounted.
  - b. Microsoft Windows XP or Windows 2000 operating systems, 733 MHz P-III processor 256MB SDRAM, 20 GB HD, CD or DVD Drive. **Standard Edition**
4. Software shall reside on the Server PC connected to a network able to poll and support over 1000 PMCS devices.
  - a. Software shall reside on the PCW connected to the network able to poll and support over 250 PMCS devices. **Standard Edition**
5. Server Software shall support 10 licensed simultaneous remote viewing connections. It shall be possible to extend the number of licensed simultaneous connections via purchase at any time.
6. Software shall support server based setup and display interface as well as one (1) licensed application viewing connection (can be used for remote viewing if not used on local machine) via IE 5.5 or higher out of the box. It is possible to extend the number of licensed simultaneous remote viewing connections to maximum of six (6) at any time. **Standard Edition**
7. Shall use the Microsoft SQL2005 database
  - a. Shall use the Microsoft MSDE database **Standard Edition**
8. PMCS Advanced Reporting shall include:
  - a. Standard Web based interface to report viewing, creation, scheduling and administrative tools.
  - b. Standard report templates that include: History tables and trends, Power Factor, Energy and Power Cost Allocation, Energy Consumption. Program shall also allow for custom report creation.
  - c. Report creation tool shall be Wizard driven.
  - d. Report presentation shall be available in a number of graphics formats such as: Trends, Tables, Histograms or Pie Charts.
  - e. Statistics on trending data for devices in the PMCS system which includes minimum and maximum values and their associated date and time stamps, average value, standard deviation and load factor.
  - f. Shall have the ability to save report outputs in a number of formats including pdf, xls, Microsoft Word <sup>TM</sup>, Rich Text Format and Crystal Reports format.

- g. Shall have the ability to send, schedule, share and network reports in and on LAN/WAN environments, including emailing these reports using SNMP.
  - h. Be able to generate either on demand or as a scheduled task to run automatically at specified intervals.
  - i. Shall have a quick reporting function to allow user to generate information quickly without having to define calculations, quantities and outputs.
  - j. Shall have the ability to view data from different devices on the same trend plot simultaneously.
  - k. Shall have the ability to filter end user access to reports by user name/login.
  - l. Shall have the ability for users to select a folder/directory structure that is intuitive to their environment and application.
9. Shall allow (with installations using a server based operation system) remote control and other administrative level functions via "SMS Setup Client" link in a browser interface.
- a. This option allows administrative level user access to system and device configuration, via browser (I.E. 6.0 SP1 or greater).
  - b. This option allows administrative level access to remote control via a GFX diagram or using the Control Output option in the SMS Setup utility.

C. Web-Enabled Interactive Graphics (GFXv4) [Must be used with PowerLogic Software]

1. The Web-Enabled Interactive Graphics Client shall only reside on the Server PC, Client PC shall not require the installation of any application software other than Internet Explorer 6.0 SP1 or higher browser to become a fully functional system.
2. Shall be a color graphics Web application that allows display of real-time information collected by the network server from the power monitoring devices on custom drawings including single line drawings, site plans or pictorial backgrounds.
3. Software shall use the following objects to display defined functions:
  - a. Analog Function Block – displays the condition of a predefined analog function.
  - b. Bar Chart – allows the creation of custom bar charts for standard or custom quantities.
  - c. Digital Function Block - displays the condition of a predefined digital function.
  - d. Digital Function Switch – box that changes color to indicate the state of an associated digital function.
  - e. Hyper Drawing Block – link to a defined Web page, drawing, report, or hyperlink.
  - f. Meter – allows the creation of custom meters using a standard or custom quantity.
  - g. Text – text object may be added to a diagram.
  - h. Value Block – displays a single quantity, also may be used to open a summary page for the associated device in a new window.
4. Software shall include a graphics software package to assist with the creation of graphics pages.(USA only due to SW licensing)
5. The Interactive Graphics software shall allow the user to zoom, scale, and scroll the drawings to the desired degree of magnification.
6. The software shall be capable of displaying status of circuit breakers (open/closed/tripped), status of transformer fans (on/off), transformer coil and motor temperatures, power factor capacitors (on/off), POWERLINK AS circuit breaker status and control, and other information available on the PMCS network. The data shall be available in multiple formats value blocks, meters, and bar charts.
7. From within any drawing the user shall have the ability to link and display drawings in a hierarchical fashion to allow quick access to related drawings.
8. Components shown on one-line diagrams shall be color-coded based on the on/off status signals from the device.
9. Custom graphic screens shall be supplied based on user drawings.

10. The software shall be able to display various file types in the directory structure to permit the user to view relevant documentation from the interface (for example-Acrobat and Word files)

D. Web-Enabled Advanced Reports

1. The Web-Enabled Interactive Graphics Client shall only reside on the Server PC, Client PC shall not require the installation of any application software other than Internet Explorer 6.0 SP1 or higher browser to become a fully functional system.

2.2 Network Architecture

- A. Fiber optics shall be installed where shown on the project drawings. Fiber optic modems and interface hardware shall be provided by the PMCS vendor as required. Use of fiber optics shall be transparent to PMCS software and monitoring devices.
- B. Wireless Ethernet shall be installed where shown on the project drawings. Wireless Ethernet and interface hardware shall be provided by the PMCS vendor as required. Use of wireless Ethernet shall be transparent to PMCS software and monitoring devices.
- C. Ethernet shall be used where shown on the project drawings. POWERLOGIC Ethernet Gateways or communication cards shall be provided by the PMCS vendor and installed as necessary. Ethernet network connections shall be established using industry standard Ethernet protocols such TCP/IP. All components shall work with existing Ethernet Gateway, Router, and Hub technology. Use of Ethernet shall be transparent to PMCS software and monitoring devices.
- D. Interface to Existing Systems or Human-Machine Interface (HMI) software packages
  1. The high-speed network utilized by the PMCS system shall permit easy interface with Automation / Process Control systems (APCS).
    - a. Data located in the power monitoring devices and PLC registers and associated inputs/outputs shall be made available to the APCS vendor via Circuit Monitor and/or programmable controller register lists.
    - b. Hardware and software required by the APCS to retrieve this data from the PMCS data highway shall be the responsibility of the APCS vendor.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. PMCS components, including Circuit Monitors, Electronic Trip Units, Transformer Temperature Monitors, Motor Protection Devices, and Digital Relays, included within the power equipment lineups shall be factory installed, wired and tested prior to shipment to the job site.
- B. All control power, CT, PT and data communications wire shall be factory wired and harnessed within the equipment enclosure.
- C. Where external circuit connections are required, terminal blocks shall be provided and the manufacturer's drawings must clearly identify the interconnection requirements including wire type to be used.
- D. All wiring required to externally connect equipment lineups shall be installed by the electrical contractor.

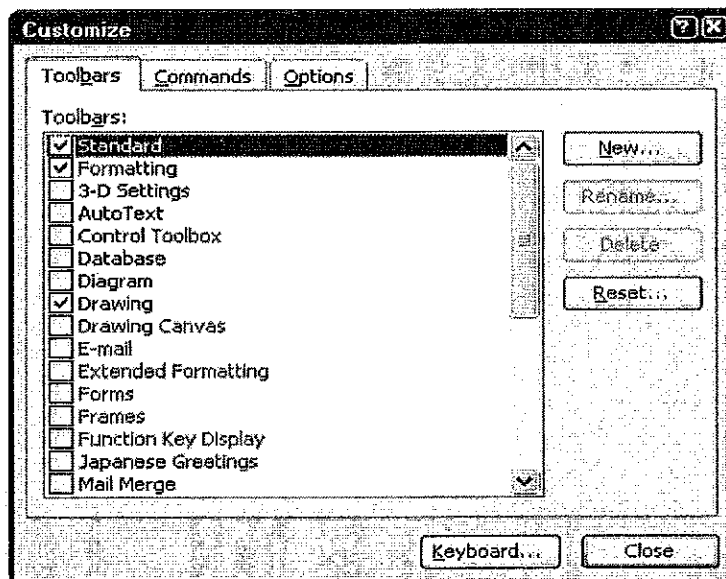
- E. Contractor interconnection wiring requirements shall be clearly identified on the PMCS system drawings.

### 3.2 SYSTEM START-UP AND TRAINING

- A. On-site start-up and training of the PMCS shall be included in the project bid.
- B. Start-up shall include a complete working demonstration of the PMCS with simulation of possible operating conditions that may be encountered.
- C. Training shall include any documentation and hands-on exercises necessary to enable electrical operations personnel to assume full operating responsibility for the PMCS after completion of the training period.
- D. The project bid shall include [ 4 ] days start-up assistance and [ 2 ] days training to include [ 2 ] trip(s).
- E. The power monitoring vendor shall offer regularly scheduled factory training for customers on all aspects of power monitoring and control, including:
  - 1. Comprehensive software and hardware setup, configuration, and operation
  - 2. Advanced monitoring and data reporting
  - 3. Advanced power quality and disturbance monitoring
- F. The power monitoring manufacturer shall provide a full time telephone technical help center for customers.

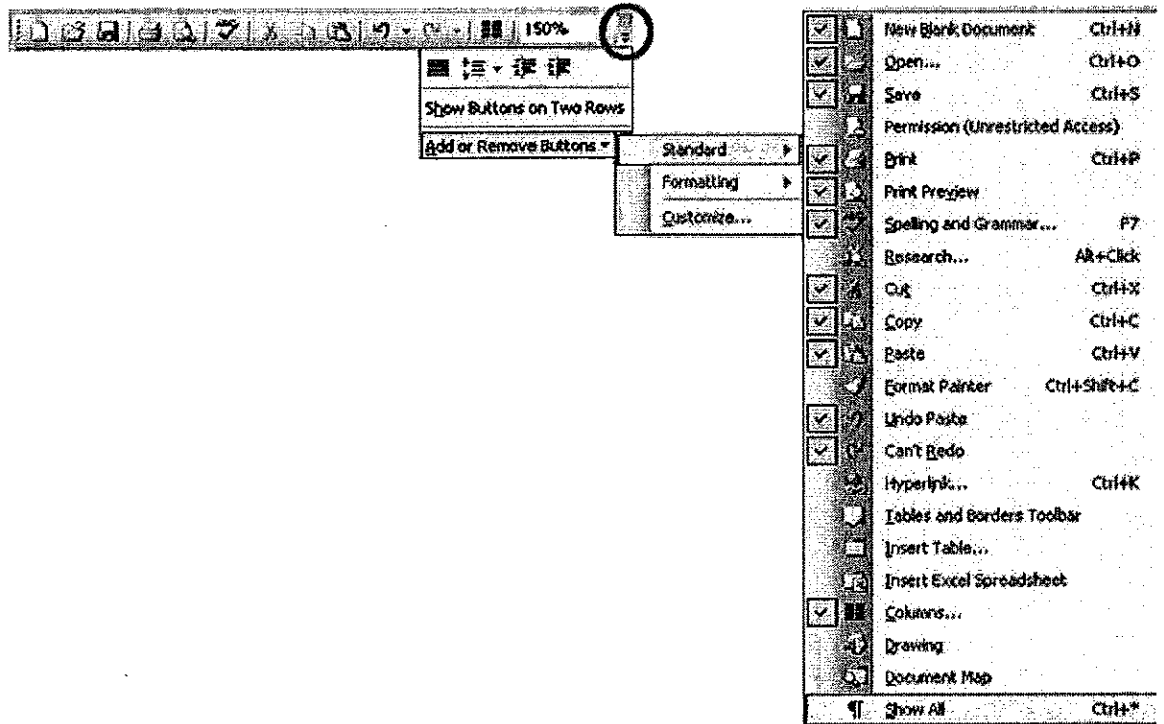
#### Accessing the Standard Tool Bar

- 1. Pull down the menu Tools.
- 2. Choose Customize.
- 3. Make sure the Standard tool bar is checked.



Adding or Removing Buttons on the Standard Tool Bar

4. Pull down the Toolbar Options arrow (shown at right inside the red circle).
5. Choose Add or Remove Buttons.
6. Choose Standard.
7. Make sure Show All button is checked.
8. Once the Show All button is in the Standard toolbar, it can be toggled for showing or hiding the hidden text.



SECTION 16216

POWER MONITORING AND CONTROL SYSTEM DEVICES

PART 1 - GENERAL

1.01 SYSTEM DESCRIPTION

- A. The PMCS shall be POWERLOGIC as manufactured by Square D Company [or approved equal]. The following types of Power Monitoring devices are to be included as part of this project and identified on the single-line drawings with the designations listed below:
1. (M) – Basic Monitoring with the features to include basic energy, demand and power quality measurements along with 80KB of on-board logging memory.
  2. (M-Int) – Intermediate Monitoring with Basic Monitoring features plus EN50160 summary, steady-state waveform capture along with 800KB of on-board logging memory.
  3. (M-Enh) – Enhanced Monitoring with Intermediate Monitoring features plus sag/swell metering/detection, disturbance waveform capture along with 800KB/8MB of on-board logging memory.
  4. (M-Adv) – Advanced Monitoring with Enhanced Monitoring features plus adaptive waveform capture, alarm set-point learning, standard transient detection and programming functions along with 16/32MB of on-board logging memory. Advanced transients and flicker detection shall be provided on monitoring devices designated as (M-AdvT).
    - a. All products shall not violate any U. S. patents.

1.02 REFERENCES

- A. All monitoring devices shall be UL 508 Listed, CSA approved, and have CE marking.
- B. The system shall comply with the applicable portions of NEMA standards. In addition, the control unit shall comply with FCC Emission Standards specified in Part 15, Sub-part J for Class A applications.

1.03 SUBMITTALS

- A. Product Data: Provide catalog sheets and technical data sheets to indicate physical data and electrical performance, electrical characteristics, and connection requirements of each device supplied under the PMCS scope of work.

1.04 QUALITY

- A. The PMCS vendor shall be ISO 9000 registered to demonstrate quality compliance.
- B. PMCS components included within the power equipment lineups shall be factory installed, wired and tested prior to shipment to the job site.



PART 2 - PRODUCTS

2.01 MONITORING DEVICES

- A. Measured Values - The monitoring devices shall provide the following, true RMS metered quantities. In addition, the monitoring devices shall record and save in nonvolatile memory the minimum and maximum values of all listed values since last reset. The monitoring devices shall also record and save in nonvolatile memory the interval minimum, maximum, and average of any of the values pre-defined over a user specified interval

1. Real-Time Readings

- a. Current (Per-Phase, 3-Phase Avg, % Unbalanced)
  - 1) Neutral and Ground M-Enh/M-Adv
- b. Voltage (L-L Per-Phase, L-L 3-Phase Avg, L-N Per-Phase, 3-Phase Avg, % Unbalanced)
- c. Real Power (Per-Phase, 3-Phase Total)
- d. Reactive Power (Per-Phase, 3-Phase Total)
- e. Apparent Power (Per-Phase, 3-Phase Total)
- f. Power Factor (True/Displacement)(Per-Phase, 3-Phase Total)
- g. Frequency
- h. THD (Current and Voltage)
- i. Temperature (Internal Ambient) M-Enh/M-Adv
- j. K-Factor (Per-Phase) M-Enh/M-Adv

2. Energy Readings

- a. Accumulated Energy (Real kWh, Reactive kVARh, Apparent kVAh) (Signed/Absolute)
- b. Incremental Energy (Real kWh, Reactive kVARh, Apparent kVAh) (Signed/Absolute)
- c. Conditional Energy (Real kWh, Reactive kVARh, Apparent kVAh) (Signed/Absolute)
- d. Reactive Energy by Quadrant

3. Demand Readings

- a. Demand Current Calculations (Per-Phase, 3-Phase Avg, Neutral )- Present and Peak
- b. Demand Voltage Calculations (L-N, L-L, Per-Phase, 3-Phase avg.) – Present and Peak (Provided for IM, EM, AM as indicated) M-Enh/M-Adv

4. Demand Calculations (3-Phase Total):

- a. Real Power
- b. Reactive Power
- c. Apparent Power

5. All power demand calculations shall use any one of the following calculation methods, selectable by the user:

- a. Thermal demand using a sliding window.

- b. Block interval, with optional sub-intervals. Block methods available are Sliding, Fixed and Rolling.
- c. Demand can be calculated using a Synchronization signal:
  - 1) Demand can be synchronized to an input pulse from an external source.
  - 2) Demand can be synchronized to a communication signal.
  - 3) Demand can be synchronized to the clock in the monitoring device

6. Power Analysis Values

- a. THD – Voltage, Current (3-Phase, Per-Phase, Neutral)
- b. Power Factor (Per-Phase, 3-Phase)
- c. Displacement Power Factor (Per-Phase, 3-Phase)
- d. Fundamental Voltage, Magnitude and Angle (Per-Phase)
- e. Fundamental Currents, Magnitude and Angle (Per-Phase)
- f. Fundamental Real Power (Per-Phase, 3-Phase)
- g. Fundamental Reactive Power (Per-Phase)
- h. Harmonic Power (Per-Phase, 3-Phase)
- i. Phase Rotation
- j. Unbalance (Current and Voltage)
- k. Harmonic Magnitudes & Angles (Per-Phase)

B. General Provisions– Common Features

- 1. All setup parameters required by the monitoring device shall be stored in nonvolatile memory and retained in the event of a control power interruption.
- 2. The monitoring device may be applied in three-phase, three- or four-wire systems as well as single phase
- 3. The monitoring device shall be capable of being applied without modification at nominal frequencies of 50, 60 or 400 Hz.
- 4. Sampling and Harmonic Resolution
  - a. The current and voltage signals shall be digitally sampled at a rate high enough to provide true rms accuracy to the 63<sup>rd</sup> harmonic (fundamental of 60 Hz). The monitoring device shall provide continuous sampling at a minimum of up to 128 samples/cycle, simultaneously on all voltage and current channels in the meter. M-Int/M-Enh (31<sup>st</sup> harmonic) M
  - b. The current and voltage signals shall be digitally sampled at a rate high enough to provide true rms accuracy to the 255<sup>th</sup> harmonic (fundamental of 60 Hz). The circuit monitor shall provide continuous sampling at a minimum of up to 512 samples/cycle, simultaneously on all voltage and current channels in the meter. M-Adv
  - c. The circuit monitor shall have a 5 MHz per channel (83,333 points per cycle at 60 Hz or 100,000 points per cycle at 50 Hz) sampling rate. M-AdvT
- 5. Current Inputs
  - a. 0-10 amps with 5 amps nominal input from CT secondary.
  - b. The monitoring device may be applied in three-phase, three- or four-wire systems. A fourth CT input shall be available to measure neutral or ground current. If the fourth CT is not used, then a residual current shall be calculated by vectoral addition of the phase currents. In four-wire connections the monitoring device shall utilize the circuit neutral common reference and not earth ground, to provide metering accuracy. M-Enh/M-Adv

6. Voltage Inputs
  - a. Maximum of 0-600 Volts AC (L-L) or 0-347 Volts AC (L-N).
7. Control Power (Devices)
  - a. The monitoring device control power shall be 90-457 VAC or 100-300 VDC.
  - b. The monitoring device control power shall be 90-305 VAC or 100-300 VDC.
8. Accuracy
  - a. The monitoring device shall comply with ANSI C12.20 Class 0.5 and IEC 60687 Class 0.5 for revenue meters.
  - b. No annual calibration shall be required to maintain this accuracy.
9. Input/Output
  - a. The monitoring device shall support multiple input/output options including digital inputs (Normal Mode, Demand Interval Synch Pulse, Time Synch Input, Conditional Energy Control), mechanical relay outputs, and analog inputs/outputs. This optional I/O shall be in the form of an option module that can be field installable. A solid state KY pulse output relay is provided as standard on all monitoring devices.
  - b. The monitoring device shall support multiple input/output options including digital inputs (Normal Mode, Demand Interval Synch Pulse, Time Synch Input, Conditional Energy Control), mechanical relay outputs, and solid state KYZ pulse output relay. This optional I/O shall be in the form of an option card that can be field installable.
10. Output Relay Control
  - a. Relay outputs shall operate either by user command sent over the communication link, or in response to a user defined alarm or event. The output relays will have normally open and normally closed contacts and can be configured to operate in several modes: Normal contact closure, latched mode, timed mode, end of power demand interval and energy pulse output.
11. EN50160 Evaluation
  - a. The monitoring device shall include EN50160 evaluations. This capability is characterized by the evaluation of certain power quality parameters. The Circuit Monitor shall be capable of reporting evaluation data. The user shall be able to reset the evaluation statistics as required
  - b. N/A for M devices  M
12. Waveform Capture
  - a. Steady State Waveform Capture
    - 1) The monitoring device shall provide steady state waveform captures of the voltage and current waveforms. Waveform capture shall be for 3 cycles or less and is initiated manually, using software.
    - 2) The monitoring device shall capture, and store in internal non-volatile memory, 128 digitally sampled data points for each cycle of each phase voltage

- 3) The monitoring device shall transmit the waveform samples over the network to the personal computer workstation for display, archival, and analysis..
  - 4) All waveforms must reflect actual circuit performance. Waveforms synthesized or composed over time shall not be acceptable.
  - 5) Steady State shall be manually initiated and provide a resolution of 512 samples/cycle M-Adv
  - 6) N/A for M devices M
- b. Disturbance Waveform Capture shall be initiated by an external contact closure or by an alarm. The Waveform shall take 128 samples/cycle for 3-30 cycles (dependent upon number of channels monitored). The number of pre-alarm cycles will be adjustable. M-Enh
  - c. Disturbance Waveform Capture shall be initiated manually or by an alarm condition and allow the user to select a resolution of 16-512 samples/cycle and up to a maximum duration of 715 cycles. M-Adv
  - d. Adaptive Waveform Capture shall be initiated manually or automatically by an alarm condition. The automatic alarm condition will capture data when the alarm condition is true and shall drop out when the condition is false. The user can select a resolution of 16-512 samples/cycle and up to a maximum duration of 88 seconds. M-Adv
  - e. Advanced Transient Waveform Capture features shall be furnished to detect and capture transient events at 83,333 samples per cycle up to a maximum duration of 2 milliseconds. The device shall be able detect and capture transient events with a duration as short as 200 nanoseconds. The monitoring device shall be able to detect and capture transients up to 10,000  $V_{peak}$  line to line. M-AdvT

### 13. Logging

- a. The monitoring device shall provide for onboard data logging. Each monitoring device shall be able to log data, alarms and events, and waveforms (if applicable). Logged information to be stored in each Power Meter include the following: Data logs, Min/Max log files of selected parameter values, Alarm logs for each user defined alarm or event and Waveform log. The meters shall offer the following on-board nonvolatile memory:
  - 1) 80KB M
  - 2) 800KB M-Int
  - 3) 8MB M-Enh
  - 4) 16/32MB M-Adv

### 14. Alarming

- a. Alarm events shall be user definable.
  - 1) Setpoint driven alarm events shall be available for voltage/current parameters, input status, and end of interval status. For each over/under metered value alarm, the user shall be able to define a pick-up, drop-out, and delay.
- b. There shall be four alarm severity levels in order make it easier for the user to respond to the most important events first.
- c. Indication of an alarm condition shall be given on the front panel.
- d. Sag/Swell alarming and detection shall be provided M-Enh/M-Adv

15. EN50160 Evaluation
  - a. The monitoring device shall include EN50160 evaluations. This capability is characterized by the evaluation of certain power quality parameters. The monitoring device shall be capable of reporting evaluation data. The user shall be able to reset the evaluation statistics as required.
    - 1) N/A for M devices M
16. Communications
  - a. The monitoring device shall communicate via RS-485 Modbus or Jbus protocol.
  - b. Using an optional Ethernet Communications Card, the monitoring device shall provide Modbus communications using Modbus TCP via an Ethernet network at 10/100Mbaud using UTP or at 100 Mbaud using a Fiber connection. The card shall have the capability to serve data over the Ethernet network accessible through a standard web browser. The monitor shall contain default pages from the factory and also have the ability for the user to create custom pages as needed.
17. Display
  - a. The monitoring device display shall be back lit LCD for easy viewing, display shall also be anti-glare and scratch resistant.
  - b. The monitoring device display shall be capable of allowing the user to view four values on one screen at the same time. A summary screen shall also be available to allow the user to view a snapshot of the system.
  - c. The monitoring device display shall allow the user to select a date/time format and the ability to create additional screens for user-specified views and/or custom quantities without overwriting existing standard screens.
  - d. The monitoring device standard display for operator viewing shall be a liquid crystal display (LCD). <OPTION> A vacuum fluorescent display (VFD) shall be provided including a proximity sensor.
18. Alarm Setpoint Learning (ASL) M-Adv
  - a. Using SMS software (3.3.2 or greater), the user can enable the monitoring device to learn the characteristics of normal operation of metered values and select alarm setpoints based on this data.
  - b. The user is able to determine the quantities to be learned and the period of time for the learning process for standard-speed and high-speed analog alarms, disturbance alarms, and waveshape alarms.
  - c. The user can configure this feature using one of two modes:
    - 1) Fixed Learning — Initially configured user setpoints are used during the entire learning period.
    - 2) Dynamic Learning — Initially configured user setpoints are temporarily replaced by learned setpoints at the interval specified by the user in SMS. The setpoints continue to be updated at the specified interval until the learning period expires.
19. Programming M-Adv
  - a. Where indicated on the drawings, the monitoring device shall be designed to run customized programs to greatly expand the Circuit Monitor's functionality for the particular installation.

- b. These programs shall be written in a monitoring device programming language similar to a compiled "BASIC" language. It shall include the following capabilities:
  - 1) Scheduled tasks
  - 2) Event Tasks
  - 3) Math functions including: add, subtract, multiple, divide, sine, cosine, square root, etc.
  - 4) Logical functions including: AND, OR, XOR, NOT, shift, etc.
  - 5) Loop commands
  - 6) Compare statements
  - 7) Counters and timers
- c. The monitoring device manufacturer shall offer custom programming services.
- d. Changing programs shall not require any physical modifications to the monitoring device, such as changing computer chips or cards. All changes shall be done via either of the communications ports.

20. Flicker M-AdvT

- a. The monitoring device shall detect and measure the flicker (50Hz or 60Hz) of an electrical system based on the IEC Standard 61000-4-15 (or IEEE 1453) when equipped with a Transient Module.
- b. The monitoring device shall measure three levels of Flicker:
  - 1) Instantaneous
  - 2) Short-term
  - 3) Long-term
- c. The user shall have the ability to view the graphical time-trend of Flicker magnitude in a semi-logarithmic format when equipped with a communications card.

21. It shall be possible to field upgrade the firmware in the monitoring devices to enhance functionality. These firmware upgrades shall be done through the communication connection and shall allow upgrades of individual meters or groups.

2.02 CIRCUIT BREAKER INTELLIGENT TRIP UNIT

A. Trip Unit (Reference Switchgear Specification # 16341)

- 1. Circuit breaker trip system shall be a MICROLOGIC electronic trip unit.
- 2. Trip Units shall incorporate "True RMS Sensing", and have LED long-time pickup indications.
- 3. Trip unit shall provide local trip indication [and capability to indicate local and remote reason for trip, i.e., overload, short circuit or ground fault.]
- 4. Trip units shall be capable of communicating on four wire MODBUS ® networks without software interfaces (black boxes).]
- 5. Trip units shall be available to provide real time metering. Metering functions include current, voltage, power and frequency. Metering accuracy shall be 1.5% current, 0.5% voltage, and 2% power. These accuracy's shall be total system including CT and meter and shall be of reading not full scale in a range of 5 – 500%.]
- 6. The standard trip unit provided shall be type "P" for power measurement functions
- 7. Trip units shall be available to provide harmonic analysis and waveform capture. Type H

## 2.03 ETHERNET SOLUTIONS

### A. Ethernet Communications Card (ECC) for Monitoring Devices

1. The ECC shall have an embedded web server inside the unit, capable of serving HTML pages with dynamic meter data displays.
2. The ECC shall connect to the Ethernet backbone via standard RJ-45 port for connection of unshielded twisted pair cable (UTP)
3. LC fiber optic connection for multimode fiber (100BaseFX)  ECC-21
4. The ECC shall support Circuit Monitors, Power Meters, and other POWERLOGIC-compatible devices through one 2 wire or 4-wire RS-485 communication port via standard daisy-chain connections. The RS-485 serial port shall operate up to 38.4k baud.
5. The ECC shall allow protocol conversion between standard Ethernet network protocols and PowerLogic (SY/MAX and Modbus/Jbus devices on the same daisy chain. )
6. The ECC shall be fully TCP/IP compliant thereby allowing the power monitoring software access to power monitoring information from anywhere on the local area network (LAN) or via the Wide Area Network (WAN).
7. The protocol used over Ethernet by the ECC shall be Modbus/TCP an international industry standard which is an open and well-defined protocol.
8. Setup of the ECC shall be accomplished via the on-board Ethernet port and a web browser. It shall also be possible via the Ethernet port to upgrade the firmware of the ECC in the field to accommodate new system features.
9. Web Pages shall be configurable to display data from all devices connected to the ECC.
10. The Ethernet card shall be capable of initiating an e-mail based on alarms in the host monitoring device
11. A dedicated ECC shall be used which requires no hardware adjustments or modifications. Standard personal computers (PCs) or programmable logic controllers (PLCs) are not acceptable as gateways to the power monitoring and control devices
12. The ECC shall derive control power directly from the monitoring device.
13. The ECC shall be UL Listed, NOM and CE and CSA certified.
14. All Ethernet cabling shall be Category 5 rated for 100baseT, or Fiber Optics rated for 100baseFX.
15. A tool shall be provided with the ECC (Ethernet Communications Card) that allows a user to create web pages for the host meter and other monitoring and protection devices from Schneider Electric that are connected to the ECC's serial port. The tool shall be wizard based allowing the user to specify the name and address for each device and create web pages with no knowledge of HTML or Java scripting.

### B. Ethernet Gateways (EGX) – Stand-Alone Devices

1. The EGX shall feature one RS-485 serial port and a second port configurable for RS-232 or RS-485 (support for 2-wire or 4-wire)
2. A single EGX, assigned a single IP address, shall provide high speed Ethernet support for up to 192 devices.
3. The EGX shall feature the following protocols: Ethernet -- MODBUS/TCP HTTP, FTP. Serial -- MODBUS, JBUS, and POWERLOGIC.
4. The EGX shall have an input voltage of 24 Vdc and a maximum burden of 8 Watts.
5. The EGX shall operate in ambient temperature of -30 to 80° C, an ambient storage temperature of - 40 to 85° C and will operate in relative humidity of 5 to 95%.
6. The EGX shall be a stand-alone product that offers various mounting configuration and includes at a minimum the following mounting options: DIN- rail mounting, Wall/Panel Mounting, Flat Surface or Desk Top.
7. The EGX shall be UL, CUL, CE, NOM and FCC class A compliant.

8. The EGX shall be compatible with Ethernet TCP/IP networks and allows users to access power monitoring information from any location on a local area network (LAN) or a wide area network (WAN).
9. The EGX shall utilize Modbus/TCP protocol as its high-speed backbone network protocol.
10. The EGX shall allow direct Ethernet connection to monitoring and protective RS-485 field devices. Power monitoring software running on a PC with a Modbus/TCP driver shall be able to access monitoring, metering, and protective data via the LAN. The PC shall be connected to the Ethernet LAN via a Network Interface Card (NIC)
11. The gateway shall provide an twisted pair connection to connect to the Ethernet backbone. The Ethernet twisted-pair port shall have: An RJ45 connector, Supports 10/100BaseT connection (10 or 100Mbit auto-negotiate), Support for both unshielded twisted-pair (UTP) as well as shielded twisted-pair (STP) wiring., LED's to indicate Ethernet activity.
12. The gateway shall include one 100 Mbit Fiber Optic port  Advanced EGX
13. The EGX shall have two serial RS-485 ports that are used to connect serial field devices to the LAN. Each RS-485 serial port shall have the following specification: Supports up to 32 serial devices without a repeater. Supports Modbus, Jbus, PowerLogic or mixed mode daisy chain devices. Supports both 2-wire or 4-wire daisy chain devices. Support for baud rates of 1200 to 38400.
14. The EGX shall have a minimum of one port that can be configured for either RS-485 or RS-232.
15. The EGX shall allow a Modbus master on one of its serial ports to request data from devices on the second serial port.
16. The EGX shall be configurable by either: Local RS-232 connection and a Hyper Terminal® interface or local or remote Ethernet connection and a standard web browser.
17. SNMP (Simple Network Management Protocol) shall be supported by the EGX according to the industry standard MIB2.
18. SNTP (Simple Network Management Protocol) shall be supported to allow date and time to synchronized to within 1 second between devices.
19. Setup of the ECC shall be accomplished via the on-board Ethernet port and a web browser. It shall also be possible via the Ethernet port to upgrade the firmware of the ECC in the field to accommodate new system features.
20. It shall also be possible via the Ethernet port to upgrade the firmware of the EGX in the field to accommodate new system features.
21. All communications cabling shall be Category 5 rated for 100baseT, or Fiber Optics rated for 100baseFX.

C. Basic EGX

1. The EGX shall provide a web based interface for device configuration and diagnostics.

D. Advanced EGX

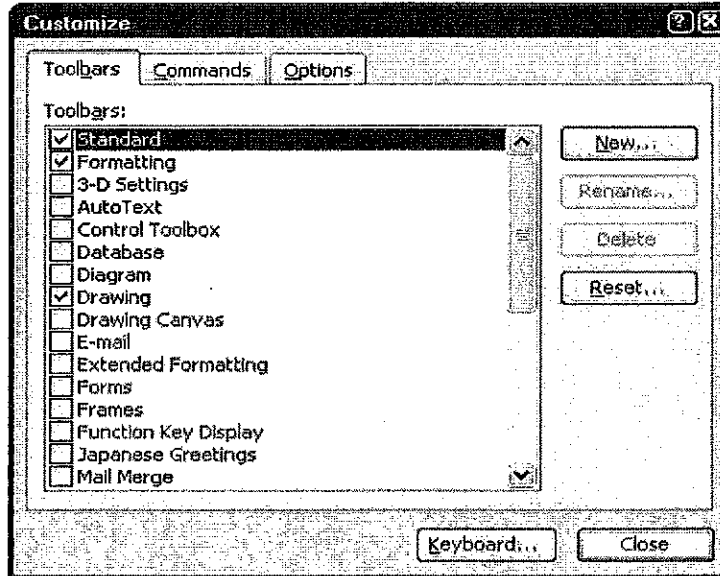
1. The advanced EGX shall feature 16 MB of internal memory.
2. The EGX shall provide storage for standard and custom web pages to display real-time power equipment data and status, instruction manuals and equipment drawings.
3. The EGX shall be capable of accepting HTML files PDF files, active X CRG, GIF, JPG graphics, MS Office files (doc, xls, ppt, etc.).
4. The on-board Web Server will provide up to 38 days of recorded interval Energy readings, for up to 32 connected devices. The readings will be stored as First In First Out quantities. The interval is configurable to 5, 15, 30, or 60 minute intervals. The data will be presented as a graph using a browser or as data points. Data can be uploaded to Microsoft Excel® for storage or additional manipulation using Microsoft Web Query, FTP (File Transport Protocol), or e-mail.
5. The EGX shall be capable of initiating an e-mail based on a user defined schedule to send logged data to a remote host in a CSV (Comma Separated Variable) file format.



6. The on-board web server is also used to configure its Ethernet and Serial communication parameters, troubleshoot both Ethernet and serial communication, and add devices.
7. The EGX shall be configured remotely using a standard Internet browser.

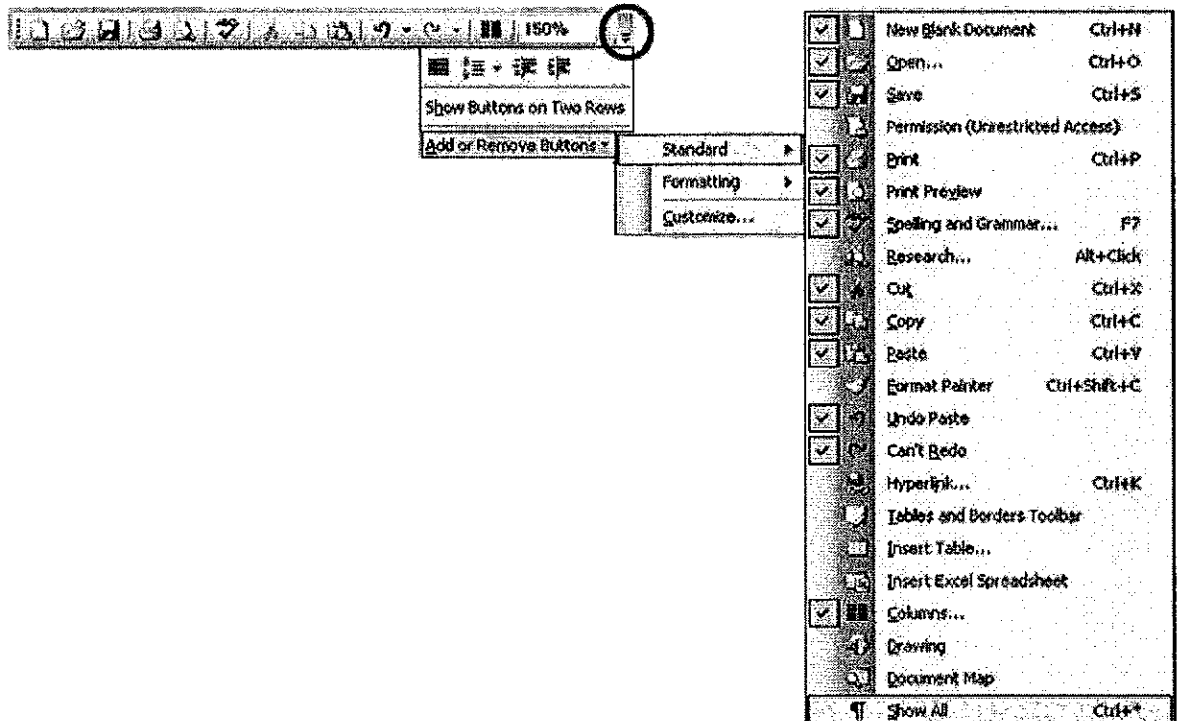
Accessing the Standard Tool Bar

1. Pull down the menu Tools.
2. Choose Customize.
3. Make sure the Standard tool bar is checked.



Adding or Removing Buttons on the Standard Tool Bar

4. Pull down the Toolbar Options arrow (shown at right inside the red circle).
5. Choose Add or Remove Buttons.
6. Choose Standard.
7. Make sure Show All button is checked.
8. Once the Show All button is in the Standard toolbar, it can be toggled for showing or hiding the hidden text.



SECTION 16231

PACKAGED ENGINE GENERATOR

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes packaged engine-generator sets for standby power supply with the following features:
  - 1. Diesel engine.
  - 2. Remote cooling system.
  - 3. Unit-mounted control and monitoring.
  - 4. Performance requirements for sensitive loads.
- B. Related Sections include the following:
  - 1. Division 16 Section "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.

1.03 DEFINITIONS

- A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.04 SUBMITTALS

- A. Product Data: For each type of packaged engine generator indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. In addition, include the following:
  - 1. Thermal damage curve for generator.
  - 2. Time-current characteristic curves for generator protective device.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.
  - 2. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
  - 3. Vibration Isolation Base Details: Signed and sealed by a qualified professional engineer. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.
  - 4. Wiring Diagrams: Power, signal, and control wiring.

- C. **Manufacturer Seismic Qualification Certification:** Submit certification that day tank, engine-generator set, batteries, battery racks, accessories, and components will withstand seismic forces defined in Division 16 Section "Electrical Supports and Seismic Restraints." Include the following:
1. **Basis for Certification:** Indicate whether withstand certification is based on actual test of assembled components or on calculation.
    - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
  2. **Dimensioned Outline Drawings of Equipment Unit:** Identify center of gravity and locate and describe mounting and anchorage provisions.
  3. **Detailed description of equipment anchorage devices** on which the certification is based and their installation requirements.
- D. **Qualification Data:** For installer manufacturer and testing agency.
- E. **Source quality-control test reports.**
1. Certified summary of prototype-unit test report.
  2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
  3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
  4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
  5. Report of sound generation.
  6. Report of exhaust emissions showing compliance with applicable regulations.
  7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.
- F. **Field quality-control test reports.**
- G. **Operation and Maintenance Data:** For packaged engine generators to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:
1. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
- H. **Warranty:** Special warranty specified in this Section.

#### 1.05 QUALITY ASSURANCE

- A. **Installer Qualifications:** Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
1. **Maintenance Proximity:** Not more than one hour normal travel time from Installer's place of business to Project site.
  2. **Engineering Responsibility:** Preparation of data for vibration isolators and seismic restraints of engine skid mounts, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.

- B. **Manufacturer Qualifications:** A qualified manufacturer. Maintain, within 100 miles of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.
  - C. **Testing Agency Qualifications:** An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL), and that is acceptable to authorities having jurisdiction.
    - 1. **Testing Agency's Field Supervisor:** Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
  - D. **Source Limitations:** Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.
  - E. **Electrical Components, Devices, and Accessories:** Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
  - F. Comply with ASME B15.1.
  - G. Comply with NFPA 37.
  - H. Comply with NFPA 70.
  - I. Comply with NFPA 99.
  - J. Comply with NFPA 110 requirements for Level 1 emergency power supply system.
  - K. Comply with UL 2200.
  - L. **Engine Exhaust Emissions:** Comply with applicable state and local government requirements.
  - M. **Noise Emission:** Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.
- 1.06 PROJECT CONDITIONS
- A. **Interruption of Existing Electrical Service:** Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
    - 1. Notify Construction Manager, Owner no fewer than two days in advance of proposed interruption of electrical service.
    - 2. Do not proceed with interruption of electrical service without Construction Manager's, Owner's written permission.
  - B. **Environmental Conditions:** Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
    - 1. Ambient Temperature: 5 to 40 deg C.
    - 2. Relative Humidity: 0 to 95 percent.
    - 3. Altitude: Sea level to 1000 feet.

1.07 COORDINATION

- A. Coordinate size and location of concrete bases for package engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.
- B. Coordinate size and location of roof curbs, equipment supports, and roof penetrations for remote radiators. These items are specified in Division 7 Section "Roof Accessories."

1.08 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

- 1. Warranty Period: Two years from date of Substantial Completion.

1.09 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

1.10 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Fuses: One for every 10 of each type and rating, but no fewer than three of each.
  - 2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
  - 3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Basis-of-Design Product:
  - 1. Caterpillar; Engine Div.
- C. Acceptable substitute manufacturer: If substitute manufacturer is selected, Contractor is responsible for all re-engineering required for a code compliant and fully functional installation.
  - 1. Onan/Cummins Power Generation; Industrial Business Group.

2.02 ENGINE-GENERATOR SET

- A. Factory-assembled and -tested, engine-generator set.

- B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.
1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.
- C. Capacities and Characteristics:
1. Power Output Ratings: Nominal ratings as indicated, with capacity as required to operate as a unit as evidenced by records of prototype testing.
  2. Output Connections: Three-phase, four wire.
  3. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.
- D. Generator-Set Performance:
1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
  2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
  3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
  4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
  5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
  6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
  7. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
  8. Start Time: Comply with NFPA 110, Type 10, system requirements.
- E. Generator-Set Performance for Sensitive Loads:
1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.
    - a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.
  2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.
  3. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.
  4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.

5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
6. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.
7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
8. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.
  - a. Provide permanent magnet excitation for power source to voltage regulator.
10. Start Time: Comply with NFPA 110, Type 10, system requirements.

### 2.03 ENGINE

- A. Fuel: Grade DF-2 (#2 Diesel Fuel).
- B. Rated Engine Speed: 1800 rpm.
- C. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm.
- D. Lubrication System: The following items are mounted on engine or skid:
  1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
  2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
  3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.
- E. Engine Fuel System:
  1. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
  2. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.
- F. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.
- G. Governor: Adjustable isochronous, with speed sensing.
- H. Cooling System: Closed loop, liquid cooled, with remote radiator (IAE Inc.) and integral engine-driven coolant pump.
  1. Configuration: Horizontal air discharge.
  2. Radiator Core Tubes: Aluminum, Nonferrous-metal construction other than aluminum.

3. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
  4. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
  5. Fan: Driven by multiple belts from engine shaft.
  6. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
  7. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
- I. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
1. Minimum sound attenuation of 25 dB at 500 Hz.
  2. Sound level measured at a distance of 10 feet from exhaust discharge after installation is complete shall be 85 dBA or less.
- J. Air-Intake Filter: Standard-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.
- K. Starting System: 24-V electric, with negative ground.
1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.
  2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
  3. Cranking Cycle: As required by NFPA 110 for system level specified.
  4. Battery: Adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycle at least three times without recharging.
  5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
  6. Battery Rack: Factory fabricated of metal with acid-resistant finish article. Include accessories required to support and fasten batteries in place.
  7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
  8. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:
    - a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
    - b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
    - c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
    - d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
    - e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either



condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.

- f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

## 2.04 FUEL OIL STORAGE

- A. Comply with NFPA 30.

- B. Day Tank: Comply with UL 142, freestanding, factory-fabricated fuel tank assembly, with integral, float-controlled transfer pump and the following features:

1. Containment: Integral rupture basin with a capacity of 150 percent of nominal capacity of day tank.
  - a. Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of day-tank leak.
2. Tank Capacity: As recommended by engine manufacturer for an uninterrupted period of 4 hours' operation at 100 percent of rated power output of engine-generator system without being refilled.
3. Pump Capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel supply pump at 110 percent of rated capacity, including fuel returned from engine.
4. Low-Level Alarm Sensor: Liquid-level device operates alarm contacts at 25 percent of normal fuel level.
5. High-Level Alarm Sensor: Liquid-level device operates alarm and redundant fuel shutoff contacts at midpoint between overflow level and 100 percent of normal fuel level.
6. Piping Connections: Factory-installed fuel supply and return lines from tank to engine; local fuel fill, vent line, overflow line; and tank drain line with shutoff valve.
7. Redundant High-Level Fuel Shutoff: Actuated by high-level alarm sensor in day tank to operate a separate motor device that disconnects day-tank pump motor. Sensor shall signal solenoid valve, located in fuel suction line between fuel storage tank and day tank, to close. Both actions shall remain in shutoff state until manually reset. Shutoff action shall initiate an alarm signal to control panel but shall not shut down engine-generator set.

## 2.05 CONTROL AND MONITORING

- A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.
- B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts generator set. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.
- C. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.
- D. Indicating and Protective Devices and Controls:

1. AC voltmeter.
  2. AC ammeter.
  3. AC frequency meter.
  4. DC voltmeter (alternator battery charging).
  5. Engine-coolant temperature gage.
  6. Engine lubricating-oil pressure gage.
  7. Running-time meter.
  8. Ammeter-voltmeter, phase-selector switch(es).
  9. Generator-voltage adjusting rheostat.
  10. Start-stop switch.
  11. Overspeed shutdown device.
  12. Coolant high-temperature shutdown device.
  13. Coolant low-level shutdown device.
  14. Oil low-pressure shutdown device.
  15. Fuel tank derangement alarm.
  16. Fuel tank high-level shutdown of fuel supply alarm.
  17. Generator overload.
- E. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.
- F. Connection to Data Link: A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication is reserved for connections for data-link transmission of indications to remote data terminals. Data system connections to terminals are covered in Division 16 Section "Electrical Power Monitoring and Control."
- G. Remote Alarm Annunciator: Comply with NFPA 99. An LED labeled with proper alarm conditions shall identify each alarm event and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.
- H. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.
- 2.06 GENERATOR OVERCURRENT AND FAULT PROTECTION
- A. Generator Circuit Breaker: Molded-case, thermal-magnetic type; 100 percent rated; complying with NEMA AB 1 and UL 489.
1. Tripping Characteristic: Designed specifically for generator protection.
  2. Trip Rating: Matched to generator rating.
  3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
  4. Mounting: Adjacent to or integrated with control and monitoring panel.
- B. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.
- 2.07 GENERATOR, EXCITER, AND VOLTAGE REGULATOR
- A. Comply with NEMA MG 1.
- B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

- C. Electrical Insulation: Class H or Class F.
- D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.
- E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
- F. Enclosure: Dripproof.
- G. Instrument Transformers: Mounted within generator enclosure.
- H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.
  - 1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.
- I. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.
- J. Windings: 0.867 pitch stator winding and fully linked amortisseur winding.
- K. Subtransient Reactance: 16 percent, maximum.

## 2.08 MOTORS

- A. General requirements for motors are specified in Division 15 Section "Motors."
  - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  - 2. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 16 Sections.

## 2.09 VIBRATION ISOLATION DEVICES

- A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.
  - 1. Material: Bridge-bearing neoprene, complying with AASHTO M 251.
  - 2. Durometer Rating: 70.
  - 3. Number of Layers: Four.

## 2.10 FINISHES

- A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

## 2.11 SOURCE QUALITY CONTROL

- A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
  - 1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.

- B. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:
1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
  2. Full load run.
  3. Maximum power.
  4. Voltage regulation.
  5. Transient and steady-state governing.
  6. Single-step load pickup.
  7. Safety shutdown.
  8. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
  9. Report factory test results within 10 days of completion of test.

### PART 3 - EXECUTION

#### 3.01 EXAMINATION

- A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.
- B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

#### 3.02 INSTALLATION

- A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.
- B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
- C. Install packaged engine generator with restrained spring isolators having a minimum deflection of 1 inch on 4-inch- high concrete base. Secure sets to anchor bolts installed in concrete bases. Concrete base construction is specified in Division 16 Section "Electrical Supports and Seismic Restraints."
- D. Install Schedule 40, black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet. Flexible connectors and steel piping materials and installation requirements are specified in Division 15 Section "Hydronic Piping."
  1. Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe with welded joints. Flexible connectors and piping materials and installation requirements are specified in Division 15 Section "Hydronic Piping."
- E. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.03 CONNECTIONS

- A. Piping installation requirements are specified in Division 15 Sections. Drawings indicate general arrangement of piping and specialties.
- B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.
- C. Connect engine exhaust pipe to engine with flexible connector.
- D. Connect fuel piping to engines with a gate valve and union and flexible connector.
  - 1. Diesel storage tanks, tank accessories, piping, valves, and specialties for fuel systems outside the building are specified in Division 2 Section "Fuel Oil Distribution."
  - 2. Diesel fuel piping, valves, and specialties inside the building are specified in Division 15 Section "Fuel Oil Piping."
- E. Ground equipment according to Division 16 Section "Grounding and Bonding."
- F. Connect wiring according to Division 16 Section "Conductors and Cables."

3.04 IDENTIFICATION

- A. Identify system components according to Division 15 Section "Mechanical Identification" and Division 16 Section "Electrical Identification."

3.05 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- C. Perform tests and inspections and prepare test reports.
  - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- D. Tests and Inspections:
  - 1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection except those indicated to be optional for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  - 2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
  - 3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
    - a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
    - b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
    - c. Verify acceptance of charge for each element of the battery after discharge.
    - d. Verify that measurements are within manufacturer's specifications.

4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
  5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
  6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg. Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
  7. Exhaust Emissions Test: Comply with applicable government test criteria.
  8. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
  9. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
  10. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations on the property line, and compare measured levels with required values.
- E. Coordinate tests with tests for transfer switches and run them concurrently.
- F. Test instruments shall have been calibrated within the last 12 months, traceable to standards of NIST, and adequate for making positive observation of test results. Make calibration records available for examination on request.
- G. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
- H. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
- I. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- J. Remove and replace malfunctioning units and retest as specified above.
- K. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
- L. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- M. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each power wiring termination and each bus connection. Remove all access panels so terminations and connections are accessible to portable scanner.
1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Substantial Completion.
  2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
  3. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.06 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators. Refer to Division 1 Section "Demonstration and Training." Owner shall have the option to videotape all demonstration and training sessions. Video equipment shall be provided by Owner.

END OF SECTION 16231

SECTION 16341

COMPACT COMPARTMENTALIZED MEDIUM VOLTAGE  
METAL-ENCLOSED LOAD INTERRUPTER SWITCHGEAR

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Medium voltage compact compartmentalized metal-enclosed switchgear with load interrupter switches.

1.02 REFERENCES

- A. ANSI / IEEE C37.20.3 - Standard for Metal-Enclosed Interrupter Switchgear.
- B. ANSI / IEEE C37.20.4 - Standard for Indoor AC Medium-Voltage Switches used in Metal-Enclosed Switchgear.
- C. ANSI / IEEE 24 - Standard Performance Characteristics and Dimensions for Outdoor Apparatus Bushings.
- D. ANSI / IEEE 48 - Standard Test Procedures and Requirements for High-Voltage Alternating-Current Cable Termination.
- E. ANSI Z55.1 - Gray Finishes for Industrial Apparatus and Equipment.
- F. NEMA
- G. IEC 420 High-Voltage Alternating Current Switch-Fuse Combinations (Applicable sections to ensure proper coordination of the switch-fuse combination when fuses are utilized for opening the switch automatically) Test Duties 4 and 5.
- H. CAN/CSA C22.2 No. 31 Switchgear Assemblies.
- I. CAN/CSA C22.2 No. 193 High Voltage Full-Load Interrupter Switches.

1.03 SUBMITTALS

- A. The metal-enclosed switchgear assembly shall be in accordance with the contract documents, applicable codes and whichever is the most stringent.
- B. The manufacturer shall furnish a detailed Bill of Material and complete set of drawings including:
  - 1. Detailed front elevation.
  - 2. Single Line
  - 3. Floor Plan
  - 4. Schematics
  - 5. Wiring Diagrams
- C. The manufacturer shall furnish comprehensive instruction manuals covering the installation of the switchgear and the operation of it's various components.



1.04 QUALITY ASSURANCE

- A. Manufacturer: Company specializing in medium voltage metal-enclosed switchgear with at least five years documented experience. The manufacturer of the switchgear must be the same as the manufacturer of the load interrupter switch.
- B. Equipment shall be UL listed and labeled for metal-enclosed type switchgear assemblies.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to site under provisions of section 01650.
- B. Store and protect products under provisions of Section 01660.
- C. Accept equipment on site and inspect for shipping damage.
- D. Protect equipment from weather and moisture by covering with heavy plastic or canvas and by maintaining heat within enclosure in accordance with manufacturer's instructions.

PART 2 - PRODUCT

2.01 MANUFACTURERS

- A. Switchgear: The metal-enclosed load interrupter switchgear shall be Square D type HVL/CC or approved equal. Submit shop drawings under the provisions of Section 01330.
- B. Current limiting fuses shall be Square D din style type or equal for 15.5kV voltage class (note: fuse size on one-line diagram). Fuses shall have a 65,000 amperes symmetrical interrupting capability at 15.5kV.
- C. The switchgear shall be equipped with an optional FUSELOGIC system to provide the following features:
  - 1. Provide direct acting, single phase protection (15.5 kV up to 125E) using Square D din style fuses (or equal) to automatically open the stored energy operated load interrupter switch when a fuse blows. For fuses at 15.5kV greater than 125E single phasing protection shall be supplied by shunt trip operation directly driven from blown fuse contact. The system shall further prevent potential single phasing conditions by blocking the closing of the switch when a fuse is blown or if a fuse is not installed.
  - 2. Provide a system to prevent potential single phase conditions by blocking the closing of a motor operated load interrupter switch when a fuse is blown or not installed.
  - 3. Fuses shall be Square D din style (or equal) non-disconnect mounted fuses with provisions for removal and replacement from the front of the switchgear.

2.02 LOAD INTERRUPTER SWITCHGEAR ASSEMBLY

- A. The metal-enclosed switchgear assembly shall be compartmentalized into the following distinct compartments:
  - 1. Main bus compartment
  - 2. Switch Compartment
  - 3. Cable connection / fuse compartment
  - 4. Mechanism compartment
  - 5. Low voltage / control compartment.

- B. The metal-enclosed switchgear with load interrupter switches shall consist of a single section line-up, be of indoor construction {in lieu of outdoor [and housed in an outdoor POWER-ZONE center]}. The sections shall contain the load interrupter switches and the necessary accessory components. The equipment shall be factory-assembled (except for necessary shipping splits) and operationally checked. The assembly shall be a self-supporting, floor mounted bay. Each incoming bay shall be 20" and each feeder bay shall be 14.75'.
- C. The equipment shall be designed for front accessibility only.
- D. Cable entry shall be top.
- E. The complete assembly shall be constructed in accordance with applicable provisions of ANSI / IEEE C37.20.3-1987 and the minimum construction standards of the manufacturers of the major components such as power fuses or potential transformers. Provide adequate space for fuse handling when applicable. For automatic fuse opening the switch-fuse combination shall meet the applicable sections of IEC 420 to ensure proper coordination of the proposed switch-fuse combination. To comply with these requirements, a time delay relay may be used for fuse ratings that do not coordinate with the switch to ensure that any fault currents have decayed to values that the load interrupter switch can safely interrupt.
- F. In establishing the requirements for the enclosure design, consideration shall be given to such relevant factors as controlled access, tamper resistance, protection from ingress of rodents and insects.
- G. The integrated fused switchgear assembly shall withstand the effects of closing, carrying and interrupting currents up to the assigned maximum short circuit rating.
- H. The switchgear shall be low maintenance designed to reduce the requirement for annual/ periodic maintenance of the equipment. Equipment with scheduled maintenance intervals of 5 or more years is preferred.
- I. Two viewing ports shall be installed in the switch enclosure to enable visible verification of the switch blade position.
- J. An animated mimic bus attached to the end of the operating shaft shall be provided to give visual indication of the position of the switch on each bay.
- K. System Voltage: 12.47 kV, three phase, solidly grounded, three phase 3 wire.
- L. Operating Frequency: 60 Hz.
- M. Maximum Short Circuit Current: 25 kA RMS Symmetrical.
- N. Maximum Design Voltage: 17.5 kV.
- O. Basic Impulse LEVEL (BIL): 95 kV.
- P. Power Frequency Withstand: 60 kV.
- Q. Short-Time Current (two second):
  - 1. Interrupter switch 25 kA.
  - 2. Grounding switch 25 kA
- R. Main Bus Ampacity: 1200 amperes, continuous.

S. Integrated Short Circuit Rating: 65kA, RMS symmetrical.

2.03 COMPONENTS

A. Stored Energy Mechanism

1. The load interrupter switch, rated 600 amperes continuous and interrupting, shall be fixed mounted motor operated, and shall be quick-make, quick-break with the speed of operation independent of the operator. The stored energy mechanism shall be equipped with separate opening and closing springs. The opening and closing springs shall be simultaneously charged in one action of the spring charging handle. Operation of the load interrupter switch shall be by means of close/open pushbuttons. Provide a 120 VAC close and trip coil. The grounding switch, upon closing, shall be quick-make with the speed of operation independent of the operator.
2. To provide for dependable operation, the device shall not rely on chains or cables to drive the blade assemblies open and closed. The operating mechanism shall be isolated from high voltage by a steel barrier and coupled through a direct drive shaft. Access to mechanism parts shall not require de-energizing of the equipment.

B. Motor Operator

1. The motor operator shall be located in the mechanism compartment and shall not alter the dimensions of the equipment. The motor operator shall have a control voltage disconnect switch accessible on front of mechanism cover with a provision for padlocking in the on and off positions. Electrical operation of the device requires a 120 VAC. The operating mechanism shall be isolated from high voltage by a steel barrier and coupled through a direct drive shaft. Access to mechanism parts shall not require de-energizing of the equipment.

C. The switch shall have three positions, open, closed and grounded.

D. The switch shall have a four-time fault close capability.

E. The switch shall be capable of 100 operations at 600 Amperes.

F. The switch shall be capable of 1000 mechanical no load operations.

G. The switch blades shall be contained in a single sealed for life enclosure. The interrupting medium pressure within the enclosure shall not exceed 6 PSI (0.4 Bars) at 5 or 15kV class equipment or 22 PSI (1.5 Bars) at 25.8 or 38kV class equipment. Refilling of the switch shall not be required. Maintenance of the interrupter module shall not be required over its life.

H. The switch operating handle shall be removable. The handle must be suitable to operate the load interrupter mechanism as well as the ground switch mechanism.

I. Voltage and Short Circuit Ratings: Match ratings specified for integrated assembly.

J. Momentary Rating: 40kA RMS Asymmetrical.

K. Fault Closing: 40 kA, RMS Asymmetrical.

- L. Load side live line indicators shall be provided as standard on the mechanism compartment. The live line indicator assembly shall be mounted in the mechanism compartment and shall be easily removable module containing three neon indicators powered from voltage dividers within the 3 standoff insulators. Optional incoming line or main bus live line indicators shall be provided as required and shall be mounted in the low voltage compartment.

#### 2.04 ACCESSORIES

- A. Provide a grounding switch on the load side of the fuses to discharge any capacitive voltage in the feeder cable prior to gaining access to the fuse compartment. Switch shall be mechanically interlocked with the main grounding switch of the load interrupter switch.
- B. Incoming Cable Termination: An anti-rotational mounting pad shall have provision for 2 single hole cable lugs.
- C. Provide mechanical lugs for terminating cables onto the switchgear terminal pads.
- D. Provide a optional low voltage compartment to accommodate control circuit terminal blocks and PowerLogic metering. The low voltage/instrument compartment door shall be hinged.
- E. Provide two 2" infrared inspection windows per vertical section. One window shall be for the lower compartment and the other for the upper compartment.
- F. Pad lock provisions for mechanism covers on the load interrupter switch and grounding switch mechanisms shall be supplied as standard to prevent unauthorized access to the operating mechanism.
- G. Surge Arrestors (Metal Oxide Type), one per phase.
- H. Mechanical Interlocks:
  - 1. An interlock shall be provided on the grounding switch mechanism to prevent insertion of the operating handle and operation of the grounding switch when the load interrupter switch is in the closed position. {Include when ground switch is specified}
  - 2. An interlock shall be provided on the load interrupter switch mechanism to prevent insertion of the operating handle and operation of the load interrupter switch when the grounding switch is in the closed position.
  - 3. An interlock shall be provided to prevent the removal of the high voltage access panel with the load interrupter switch closed. To access the high voltage compartment, the load interrupter switch must be opened and the grounding switch must be in the closed position. The interlock must be directly attached to the operating mechanism and should not rely on long cables and linkages.
  - 4. To facilitate cable testing in the high voltage compartment, the grounding switch can be returned to the open position. In this position interlocks are to be provided to prevent replacement of the high voltage access panel and prevent closure of the load interrupter switch. {Include when ground switch is specified}
- N. Metering Options:
  - 1. Each bay containing a load interrupter switch shall include the following:
    - a. PowerLogic Circuit Monitor, with digital display wired for communications to other devices.
    - b. PowerLogic System Display

- c. PowerLogic digital meter.
- d. Ammeter with Selector Switch, 1% Accuracy.
- e. Voltmeter with Selector Switch, 1% Accuracy.

O. Automatic Load Transfer Control:

1. An automatic load transfer system shall be provided for a Main-Main (Common-Bus Primary-Selective System) arrangement. The system shall automatically control motor operated load interrupter switches to provide transfer of the medium-voltage circuit to an alternate circuit upon loss of voltage of the normal source(s). Potential transformers feeding phase balance and undervoltage relays are provided to continuously monitor all three phases on both sources.
2. The system shall consist of a **MODICON** programmable logic controller or a relay system, potential transformers, control power transfer contactor, control selector switches, two three-phase, phase-balance/undervoltage (47N/27) relays, and status indicating lights.
3. The potential transformers shall also provide 120 VAC control power for the motor operators and the logic control. Other accessories for the system include:
  - a. 1- Auto/Manual selector switch with indicating lights.
  - b. 1- Hold Return/Auto Return selector switch with indicating lights.
  - c. 1- Closed Transition/Open Transition selector switch with indicating lights.
  - d. 1- Preferred Source selector switch with indicating lights (main-main system).
  - e. 2- Undervoltage test push buttons.
  - f. 2- Close push buttons with indicating lights.
  - g. 2- Open bush buttons with indicating lights.
4. Sequence of operation:
  - a. Main - Main System:
    - 1) The normal conditions shall be with one source (designated as preferred) closed and with the other source (designate as the alternate) open but available to provide power. A transfer is initiated after a six (6) second time delay upon detection of a phase unbalance and/or undervoltage condition on the preferred source. The normal source switch will open within three (5) cycles after the time delay. The alternate source switch will close within 5 cycles after the time delay. The re-transfer will occur after the voltage on the normal source returns and stabilizes for five (5) minutes. The time registers are adjustable by the use of a hand held programmer.
    - 2) The automatic transfer switches shall be equipped with a motor operator, close coil and opening coil.
    - 3) The two switches shall be electrically and mechanically interlocked to prevent inadvertent paralleling of the preferred and alternate sources.

2.05 FABRICATION

- A. Construction: Indoor. Each equipment bay shall be a separately constructed cubicle assembled to form a rigid free standing unit. Minimum sheet metal thickness shall be 11 gauge steel on all exterior surfaces. Adjacent bays shall be securely bolted together to form an integrated rigid structure. Each individual unit shall be braced to prevent distortion.
- B. All bus joints shall use Belleville washers. Torque bolts that are used for bus joints or for insulators and direct support of any current carrying parts shall be marked with a bead of highly visible bright orange "torque seal", that will readily show when a bolt has loosened.

- C. The high voltage non-disconnect type fuses (when required), shall be accessible only through a separate panel mechanically interlocked with the switch. Where grounding switches are supplied, access panels shall not be removable unless the grounding switch is in the closed position. If grounding switches are defeated, access panels shall not be removable unless the load interrupter switch is in the fully open position. Screened or penetrable barriers which may allow intentional or inadvertent contact with energized parts shall not be permitted.
- D. The duplex switch configuration shall be equipped with a mechanical interlock between the two switches preventing paralleling of the two incoming lines. A single access panel shall be provided to the load side of the duplex configuration requiring that both switches shall be opened and grounded prior to accessing the fuses and load cable terminations.
- E. Height: 90 inches, maximum including auxiliary support members on top and bottom.
- F. Main bus shall be tin-plated copper, insulated rated 1200 amps, and shall be supported directly by the switch.
- G. For multiple bay lineups, include continuous ground bus through the switchgear assembly, securely connected to the steel frame of each cubicle.
- H. Main bus and ground bus connections shall be designed for easy for future extensions. Cutout areas with removable bolted on covers shall allow for future extension of the main bus. A knock-out shall be removable for the extension of the ground bus.
- I. The metal-enclosed switchgear shall be fully assembled, inspected and tested at the factory prior to shipment. Large line-ups shall be split to permit normal shipping and handling as well as for ease of rejoining at the job site.

## 2.06 FACTORY FINISHING

- A. All non-painted steel parts shall be zinc plated.
- B. All painted steel parts shall be cleaned and an iron phosphate (indoor equipment) pre-treatment applied prior to paint application
- C. Paint Color shall be ANSI-61 (light gray) TGIC polyester powder, applied electrostatically through air. Following paint application, parts shall be baked to produce a hard durable finish. The average thickness of the paint film shall be 2.0 mils. Paint film shall be uniform in color and free from blisters, sags, flaking and peeling.
- D. Adequacy of paint finish to inhibit the buildup of rust on ferrous metal materials shall be tested and evaluated per paragraphs 5.2.8.1-7 of ANSI C37.20.3-1987. Salt spray withstand tests in accordance with paragraph 5.2.8.4 shall be performed on a periodic basis to provide conformance to this corrosion resistance standard of at least 2500 hours minimum (outdoor equipment) or 600 hours minimum (indoor equipment).

## PART 3 - EXECUTION

### 3.01 EXAMINATION

- A. Visually inspect switchgear for evidence of damage and verify that surfaces are ready to receive work.
- B. Visually inspect to confirm that all items and accessories are in accordance with specifications and drawings.

- C. Verify field measurements are as shown on Drawings and shown on shop drawings.
- D. Beginning of installation means installer accepts existing surface conditions.

### 3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions, applicable requirements of the NEC and in accordance with recognized industry practices.
- B. Bending of high-voltage cables should be avoided or minimized. All necessary bends should meet at least the minimum radii specified by the cable manufacturer.
- C. Connect the primary surge arrestors if not connected. If required, use jumper cables, as provided by the switchgear manufacturer.

### 3.03 FIELD QUALITY CONTROL

- A. Field inspection and testing will be performed by the installing contractor under provisions of Section 01400.
- B. Visually inspect switchgear for physical damage upon receipt.
- C. Perform mechanical operator tests in accordance with manufacturer's instructions.
- D. Check torque of all bolted connections, including cable terminations, either by observing the bead of indicating compound to confirm that it is still intact, or with a torque wrench to confirm the joint is tightened to the manufacturer's specifications.
- E. Touch-up all chips and scratches with manufacturer-supplied paint and leave remaining paint with Owner.
- F. Verify key interlock operation if applicable.
- G. Perform insulation resistance test on each phase to ground and phase to phase. Record results for future reference.
- H. Perform low-frequency withstand tests according to ANSI/IEEE C37.20.3, paragraph 5.5.
- I. Perform contact resistance test across each switch blade; report any contact resistance in excess of 50 micro-ohms.

END OF SECTION 16341

SECTION 16410

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following individually mounted, enclosed switches and circuit breakers:
  - 1. Fusible switches.
  - 2. Nonfusible switches.
  - 3. Molded-case circuit switches.
  - 4. Molded-case switches.
  - 5. Enclosures.

1.03 DEFINITIONS

- A. GD: General duty.
- B. GFCI: Ground-fault circuit interrupter.
- C. HD: Heavy duty.
- D. RMS: Root mean square.
- E. SPDT: Single pole, double throw.

1.04 SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
  - 1. Enclosure types and details for types other than NEMA 250, Type 1.
  - 2. Current and voltage ratings.
  - 3. Short-circuit current rating.
  - 4. UL listing for series rating of installed devices.
  - 5. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Manufacturer Seismic Qualification Certification: Submit certification that enclosed switches and circuit breakers, accessories, and components will withstand seismic forces defined in Division 16 Section 16072. Include the following:
  - 1. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
    - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."



2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Qualification Data: For testing agency.
- E. Field quality-control test reports including the following:
1. Test procedures used.
  2. Test results that comply with requirements.
  3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- F. Manufacturer's field service report.
- G. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section, "Operation and Maintenance Data," include the following:
1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
  2. Time-current curves, including selectable ranges for each type of circuit breaker.

#### 1.05 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the International Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
1. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NFPA 70.
- D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

#### 1.06 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
  2. Altitude: Not exceeding 6600 feet.

#### 1.07 COORDINATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.08 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Spares: For the following:
    - a. Potential Transformer Fuses: 3 of each type
    - b. Control-Power Fuses: 3 of each type
    - c. Fuses and Fusible Devices for Fused Circuit Breakers: 3 of each type
    - d. Fuses for Fusible Switches: 3 of each type
    - e. Fuses for Fused Power Circuit Devices: 3 of each type
  2. Spare Indicating Lights: Six of each type installed.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
1. Manufacturers: Subject to compliance with requirements; provide products by one of the manufacturers specified.

2.02 FUSIBLE AND NONFUSIBLE SWITCHES

- A. Manufacturers:
1. Eaton Corporation; Cutler-Hammer Products.
  2. General Electric Co.; Electrical Distribution & Control Division.
  3. Siemens Energy & Automation, Inc.
  4. Square D/Group Schneider.
- B. Fusible Switch, 600A and Smaller: NEMA KS 1, Type HD, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.
- C. Nonfusible Switch, 600A and Smaller: NEMA KS 1, Type HD, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.
- D. Accessories:
1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
  2. Neutral Kit: Internally mounted; insulated, capable of being grounded, and bonded; and labeled for copper and aluminum neutral conductors.
  3. Auxiliary Contact Kit: Auxiliary set of contacts arranged to open before switch blades open.

2.03 MOLDED CASE CIRCUIT BREAKERS AND SWITCHES

- A. Manufacturers:
1. Eaton Corporation; Cutler-Hammer Products.
  2. General Electric Co.; Electrical Distribution & Control Division.
  3. Moeller Electric Corporation.
  4. Siemens Energy & Automation, Inc.
  5. Square D/Group Schneider.

- B. Molded Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.
1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250A and larger.
  2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
  3. Electronic Trip-Unit Circuit Breakers: RMS sensing; field-replaceable rating plug; with the following field-adjustable settings:
    - a. Instantaneous trip.
    - b. Long- and short-time pickup levels.
    - c. Long- and short-time time adjustments.
    - d. Ground-fault pickup level, time delay, and  $I^2t$  response.
  4. Current-Limiting Circuit Breakers: Frame sizes 400A and smaller and let-through ratings less than NEMA FU 1, RK-5.
  5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.
  6. GFCI Circuit Breakers: Single- and two-pole configurations with 30mA trip sensitivity.
- C. Molded Case Circuit Breaker Features and Accessories:
1. Standard frame sizes, trip ratings, and number of poles.
  2. Lugs: Mechanical style with compression lug kits suitable for number, size, trip ratings, and conductor material.
  3. Application Listing: Type SWD for switching fluorescent lighting loads; Type HACR for heating, air conditioning, and refrigerating equipment.
  4. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
  5. Shunt Trip: 120V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
  6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
  7. Auxiliary Switch: One SPDT with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
  8. Key Interlock Kit: Externally mounted to prohibit circuit breaker operation; key shall be removable only when circuit breaker is in off position.
  9. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground fault protection function.
- D. Molded Case Switches: Molded case circuit breaker with fixed, high-set instantaneous trip only, and short circuit withstand rating equal to equivalent breaker frame size interrupting rating.
- E. Molded Case Switch Accessories:
1. Lugs: Mechanical style with compression lug kits suitable for number, size, trip ratings, and material of conductors.
  2. Application Listing: Type HACR for heating, air-conditioning, and refrigerating equipment.
  3. Shunt Trip: 120V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage. Provide "dummy" trip unit where required for proper operation.
  4. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay. Provide "dummy" trip unit where required for proper operation.

5. Auxiliary Switch: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
6. Key Interlock Kit: Externally mounted to prohibit operation; key shall be removable only when switch is in off position.

#### 2.04 ENCLOSURES

- A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location.
  1. Outdoor Locations: NEMA 250, Type 3R.
  2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
  3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

### PART 3 - EXECUTION

#### 3.01 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

#### 3.02 CONCRETE BASES

- A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.
- B. Concrete base is specified in Division 16 Section 16050, "Basic Electrical Methods," and concrete materials and installation requirements are specified in Division 3.

#### 3.03 INSTALLATION

- A. Comply with applicable portions of NECA 1, NEMA PB 1.1, and NEMA PB 2.1 for installation of enclosed switches and circuit breakers.
- B. Mount individual wall-mounting switches and circuit breakers with tops at uniform height, unless otherwise indicated. Anchor floor-mounting switches to concrete base.
- C. Comply with mounting and anchoring requirements specified in Division 16 Section 16072, "Electrical Supports and Seismic Considerations."
- D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

#### 3.04 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Sections 16050, "Basic Electrical Methods" and 16075, "Electrical Identification."
- B. Enclosure Nameplates: Label each enclosure with engraved metal or laminated-plastic nameplate as specified in Division 16 Sections 16050, "Basic Electrical Methods" and 16075, "Electrical Identification."

#### 3.05 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

- B. Prepare for acceptance testing as follows:
1. Inspect mechanical and electrical connections.
  2. Verify switch and relay type and labeling verification.
  3. Verify rating of installed fuses.
  4. Inspect proper installation of type, size, quantity, and arrangement of mounting or anchorage devices complying with manufacturer's certification.
- C. Perform the following field tests and inspections and prepare test reports:
1. Test mounting and anchorage devices according to requirements in Division 16 Section 16072.
  2. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
  3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
  4. Infrared Scanning:
    - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Open or remove doors or panels so connections are accessible to portable scanner.
    - b. Follow-Up Infrared Scanning: Perform an additional follow-up infrared scan of each unit 11 months after date of Substantial Completion.
    - c. Instruments, Equipment and Reports:
      - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
      - 2) Prepare a certified report that identifies enclosed switches and circuit breakers included and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

### 3.06 ADJUSTING AND CLEANING

- A. Set field-adjustable switches and circuit-breaker trip ranges.
- B. On completion of installation, vacuum dirt and debris from interiors; do not use compressed air to assist in cleaning.
- C. Inspect exposed surfaces and repair damaged finishes.

END OF SECTION 16410

SECTION 16415

TRANSFER SWITCHES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes transfer switches rated 600V and less, including the following:
  - 1. Automatic transfer switches.

1.03 SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Dimensioned plans, sections, and elevations showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.

- 1. Wiring Diagrams: Single-line diagram. Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.

- C. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches, accessories, and components will withstand seismic forces defined in Division 16 Section 16072, "Electrical Supports and Seismic Considerations." Include the following:

- 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

- a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

- 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

- 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

- D. Qualification Data: For manufacturer.

- E. Field quality-control test reports.

- F. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section, "Operation and Maintenance Data," include the following:

- 1. Features and operating sequences, both automatic and manual.

2. List of all factory settings of relays; provide relay setting and calibration instructions, including software, where applicable.

#### 1.04 QUALITY ASSURANCE

- A. **Manufacturer Qualifications:** Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.
- B. **Testing Agency Qualifications:** An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the International Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
  1. **Testing Agency's Field Supervisor:** Person currently certified by the International Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- C. **Source Limitations:** Obtain automatic transfer switches, bypass/isolation switches, nonautomatic transfer switches, remote annunciators, and remote annunciator and control panels through one source from a single manufacturer.
- D. **Electrical Components, Devices, and Accessories:** Listed and labeled as defined in NFPA 70, Article 100, for emergency service under UL 1008, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with NEMA ICS 1.
- F. Comply with NFPA 70.
- G. Comply with NFPA 99.
- H. Comply with NFPA 110.
- I. Comply with UL 1008 unless requirements of these Specifications are stricter.

### PART 2 - PRODUCTS

#### 2.01 MANUFACTURERS

- A. See Editing Instruction No. 1 in the Evaluations for cautions about naming manufacturers and products.
  1. **Contactor Transfer Switches:**
    - a. Russelectric, Inc.
    - b. ASCO

#### 2.02 GENERAL TRANSFER SWITCH PRODUCT REQUIREMENTS

- A. **Indicated Current Ratings:** Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.
- B. **Tested Fault Current Closing and Withstand Ratings:** Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.

1. Where transfer switch includes internal fault current protection, rating of switch and trip unit combination shall exceed indicated fault current value at installation location.
  - C. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels have communication capability matched with remote device.
  - D. Solid-State Controls: Repetitive accuracy of all settings is plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.
  - E. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
  - F. Neutral Terminal: Switched and fully rated.
  - G. Transfer switches shall be arranged for front access only.
  - H. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.
  - I. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color code or by numbered or lettered wire and cable tape markers at terminations.
    1. Designated Terminals: Pressure type suitable for types and sizes of field wiring indicated.
    2. Power Terminal Arrangement and Field Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
    3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
  - J. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.
  - K. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
    1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit breaker components are not acceptable.
    2. Switch Action: Double throw; mechanically held in both directions.
    3. Contacts: Silver composition or silver alloy for load current switching. Conventional automatic transfer switch units rated 225A and higher, shall have separate arcing contacts.
- 2.03 AUTOMATIC TRANSFER SWITCHES
- A. Comply with Level 1 equipment according to NFPA 110.
  - B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.
  - C. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.
  - D. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.



- E. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.
- F. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.
- G. Transfer Switches Based on Molded-Case Switch Components: will not be considered.
- H. In-Phase Monitor: (Life Safety and Critical Branch only) Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.
- I. Programmed Neutral Switch Position: (Equipment Branch only) Switch operator has a programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Pause is adjustable from 0.5 to 30 seconds minimum and factory set for 0.5 second, unless otherwise indicated. Time delay occurs for both transfer directions. Pause is disabled unless both sources are live.

#### 2.04 AUTOMATIC TRANSFER SWITCH FEATURES

- A. Undervoltage Sensing for Each Phase of Normal Source: Senses low phase-to-ground voltage on each phase. Pickup voltage is adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
- B. Time delay for override of normal-source voltage sensing delays transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
- C. Voltage/Frequency Lockout Relay: Prevents premature transfer to generator. Pickup voltage is adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency is adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
- D. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes. Provides automatic defeat of delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
- E. Test Switch: Simulates normal-source failure.
- F. Switch-Position Pilot Lights: Indicate source to which load is connected.
- G. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
  - 1. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
  - 2. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."
- H. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10A at 240Vac.

- I. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
  - J. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10A at 32Vdc minimum.
  - K. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
  - L. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
  - M. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
    - 1. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
    - 2. Push-button programming control with digital display of settings.
    - 3. Integral battery operation of time switch when normal control power is not available.
  - N. Equipment Branch Automatic Transfer Switches shall be equipped with Optional Load Shed Relay.
- 2.05 BYPASS/ISOLATION SWITCHES
- A. Comply with requirements for Level 1 equipment according to NFPA 110.
  - B. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the following features for each combined automatic transfer switch and bypass/isolation switch:
    - 1. Means to lock the bypass/isolation switch in the position that isolates the transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. While isolated, interlocks prevent transfer-switch operation, except for testing or maintenance.
    - 2. Drawout Arrangement for Transfer Switch: Provides physical separation from live parts and accessibility for testing and maintenance operations.
    - 3. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.
    - 4. Contact temperatures of bypass/isolation switches do not exceed those of automatic transfer-switch contacts when they are carrying rated load.
    - 5. Operability: Constructed so load bypass and transfer-switch isolation can be performed by 1 person in no more than 2 operations in 15 seconds or less.
    - 6. Legend: Manufacturer's standard legend for control labels and instruction signs give detailed operating instructions.
    - 7. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.

- C. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.

2.06 FINISHES

- A. Enclosures: Manufacturer's standard enamel over corrosion-resistant pretreatment and primer.

2.07 SOURCE QUALITY CONTROL

- A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Comply with mounting and anchoring requirements specified in Division 16 Section 16072, "Electrical Supports and Seismic Considerations."
- B. Floor-Mounted Switch: Anchor to floor by bolting.
  - 1. Concrete Bases: 4 inches high, reinforced, with chamfered edges. Extend base no more than 2 inches in all directions beyond the maximum dimensions of switch, unless otherwise indicated. Cast anchor-bolt inserts into bases. Comply with Division 3 Section, "Cast-in-Place Concrete."
- C. Annunciator and Control Panel Mounting: Flush in wall, unless otherwise indicated.
- D. Identify components according to Division 16 Sections 16050, "Basic Electrical Methods" and 16075, "Electrical Identification."

3.02 WIRING TO REMOTE COMPONENTS

- A. Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

3.03 CONNECTIONS

- A. Ground equipment according to Division 16 Section 16060, "Grounding and Bonding."
- B. Connect wiring according to Division 16 Section 16120, "Conduit and Cables."
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.04 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections and prepare test reports:

1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
  2. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.22.3. Certify compliance with test parameters.
  3. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
    - a. Check for electrical continuity of circuits and for short circuits.
    - b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
    - c. Verify that manual transfer warnings are properly placed.
    - d. Perform manual transfer operation.
  4. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
    - a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
    - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
    - c. Verify time-delay settings.
    - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
    - e. Test bypass/isolation unit functional modes and related automatic transfer switch operations.
    - f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
    - g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
  5. Ground Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
    - a. Verify grounding connections and locations and ratings of sensors.
    - b. Observe reaction of circuit interrupting devices when simulated fault current is applied at sensors.
- C. Coordinate tests with tests of generator and run them concurrently.
- D. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- E. Remove and replace malfunctioning units and retest as specified above.

3.05 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below. Refer to Division 1 Section, "Demonstration and Training." Owner shall have the option to videotape all demonstration and training sessions. Video equipment shall be provided by Owner.
  - 1. Coordinate this training with that for generator equipment.

END OF SECTION 16415

SECTION 16441

SWITCHBOARDS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes service and distribution switchboards rated 600 V and less.

1.03 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground-fault circuit interrupter.
- C. RFI: Radio-frequency interference.
- D. RMS: Root mean square.
- E. SPDT: Single pole, double throw.

1.04 SUBMITTALS

- A. Product Data: For each type of switchboard, overcurrent protective device, transient voltage suppression device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each switchboard and related equipment.
  - 1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
    - a. Enclosure types and details for types other than NEMA 250, Type 1.
    - b. Bus configuration, current, and voltage ratings.
    - c. Short-circuit current rating of switchboards and overcurrent protective devices.
    - d. Descriptive documentation of optional barriers specified for electrical insulation and isolation.
    - e. Utility company's metering provisions with indication of approval by utility company.
    - f. Mimic-bus diagram.
    - g. UL listing for series rating of installed devices.
    - h. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
  - 2. Wiring Diagrams: Power, signal, and control wiring.
- C. Samples: Representative portion of mimic bus with specified finish, for color selection.

- D. **Manufacturer Seismic Qualification Certification:** Submit certification that switchboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 16 Section "Electrical Supports and Seismic Restraints." Include the following:
1. **Basis for Certification:** Indicate whether withstand certification is based on actual test of assembled components or on calculation.
    - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
  2. **Dimensioned Outline Drawings of Equipment Unit:** Identify center of gravity and locate and describe mounting and anchorage provisions.
  3. **Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.**
- E. **Qualification Data:** For testing agency.
- F. **Field quality-control test reports including the following:**
1. Test procedures used.
  2. Test results that comply with requirements.
  3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- G. **Operation and Maintenance Data:** For switchboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:
1. Routine maintenance requirements for switchboards and all installed components.
  2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
  3. Time-current curves, including selectable ranges for each type of overcurrent protective device.

#### 1.05 QUALITY ASSURANCE

- A. **Testing Agency Qualifications:** An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
1. **Testing Agency's Field Supervisor:** Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- B. **Testing Agency Qualifications:** An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.
- C. **Source Limitations:** Obtain switchboards through one source from a single manufacturer.
- D. **Product Selection for Restricted Space:** Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
  - F. Comply with NEMA PB 2, "Deadfront Distribution Switchboards."
  - G. Comply with NFPA 70.
- 1.06 DELIVERY, STORAGE, AND HANDLING
- A. Deliver in sections or lengths that can be moved past obstructions in delivery path.
  - B. Store indoors in clean dry space with uniform temperature to prevent condensation. Protect from exposure to dirt, fumes, water, corrosive substances, and physical damage.
  - C. If stored in areas subjected to weather, cover switchboards to provide protection from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside switchboards; install electric heating (250 W per section) to prevent condensation.
  - D. Handle switchboards according to NEMA PB 2.1 and NECA 400.
- 1.07 PROJECT CONDITIONS
- A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.
  - B. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
    - 1. Ambient Temperature: Not exceeding 104 deg F.
    - 2. Altitude: Not exceeding 6600 feet.
  - C. Service Conditions: NEMA PB 2, usual service conditions, as follows:
    - 1. Ambient temperatures within limits specified.
    - 2. Altitude not exceeding 6600 feet.
  - D. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
    - 1. Notify Construction Manager, Owner no fewer than seven days in advance of proposed interruption of electric service.
    - 2. Indicate method of providing temporary electric service.
    - 3. Do not proceed with interruption of electric service without Construction Manager's, Owner's written permission.
- 1.08 COORDINATION
- A. Coordinate layout and installation of switchboards and components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.



- B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

1.09 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Potential Transformer Fuses: Equal to 10 percent of amount installed for each size and type, but no fewer than 3 of each size and type.
  - 2. Control-Power Fuses: Equal to 10 percent of amount installed for each size and type, but no fewer than 3 of each size and type.
  - 3. Fuses and Fusible Devices for Fused Circuit Breakers: Equal to 10 percent of amount installed for each size and type, but no fewer than 3 of each size and type.
  - 4. Fuses for Fused Switches: Equal to 10 percent of amount installed for each size and type, but no fewer than 3 of each size and type.
  - 5. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of amount installed for each size and type, but no fewer than 3 of each size and type.
  - 6. Indicating Lights: Equal to 10 percent of amount installed for each size and type, but no fewer than 2 of each size and type.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.02 MANUFACTURED UNITS

- A. Manufacturers:
  - 1. Square D.
  - 2. General Electric
- B. Front-Connected, Front-Accessible Switchboard: Fixed, individually mounted main device, panel-mounted branches, and sections rear aligned.
- C. Front- and Side-Accessible Switchboard: Fixed, individually mounted main device; panel-mounted branches; and sections rear aligned.
- D. Front- and Rear-Accessible Switchboard: Front and rear aligned, with features as follows:
  - 1. Main Devices: Fixed, individually mounted.
  - 2. Branch Devices: Panel and fixed, individually mounted.
- E. Nominal System Voltage: 480Y/277 V.
- F. Main-Bus Continuous: 3000 A.
- G. Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Division 16 Section "Electrical Supports and Seismic Restraints."

- H. Enclosure: Steel, NEMA 250, Type 1.
- I. Enclosure Finish for Outdoor Units: Factory-applied finish in manufacturer's standard color, undersurfaces treated with corrosion-resistant undercoating.
- J. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
- K. Barriers: Between adjacent switchboard sections.
- L. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.
- M. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.
- N. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.
- O. Pull Box on Top of Switchboard:
  - 1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
  - 2. Set back from front to clear circuit-breaker removal mechanism.
  - 3. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
  - 4. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
  - 5. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.
- P. Buses and Connections: Three phase, four wire, unless otherwise indicated.
  - 1. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity with feeder circuit-breaker line connections.
  - 2. Phase- and Neutral-Bus Material: Tin-plated, high-strength, electrical-grade aluminum alloy with copper- or tin-plated, aluminum circuit-breaker line connections.
  - 3. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity or tin-plated, high-strength, electrical-grade aluminum alloy.
    - a. If bus is aluminum, use copper- or tin-plated aluminum for circuit-breaker line connections.
    - b. If bus is copper, use copper for feeder circuit-breaker line connections.
  - 4. Load Terminals: Insulated, rigidly braced, silver-plated, copper runback bus extensions equipped with pressure connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full ampere rating of circuit-breaker position.
  - 5. Ground Bus: 1/4-by-2-inch- minimum-size, hard-drawn copper of 98 percent conductivity, equipped with pressure connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
  - 6. Contact Surfaces of Buses: Silver plated.
  - 7. Main Phase Buses, Neutral Buses, and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
  - 8. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.

9. Neutral Buses: 50 percent of the ampacity of phase buses, unless otherwise indicated, equipped with pressure connectors for outgoing circuit neutral cables. Bus extensions for busway feeder neutral bus are braced.
10. Neutral Buses: 100 percent of the ampacity of phase buses, unless otherwise indicated, equipped with pressure connectors for outgoing circuit neutral cables. Bus extensions for busway feeder neutral bus are braced.

- Q. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.
- R. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating: 105 deg C.

## 2.03 TRANSIENT VOLTAGE SUPPRESSION DEVICES

- A. IEEE C62.41, integrally mounted, plug-in-style, solid-state, parallel-connected, sine-wave tracking suppression and filtering modules.
- B. Minimum single-impulse current rating shall be as follows:
1. Line to Neutral: 100,000 A.
  2. Line to Ground: 100,000 A.
  3. Neutral to Ground: 50,000 A.
- C. Protection modes shall be as follows:
1. Line to neutral.
  2. Line to ground.
  3. Neutral to ground.
- D. EMI/RFI Noise Attenuation Using 50-ohm Insertion Loss Test: 55 dB at 100 kHz.
- E. Maximum Category C combination wave clamping voltage shall not exceed 1000 V, line to neutral and line to ground on 277/480 V systems.
- F. Maximum UL 1449 clamping levels shall not exceed 800 V, line to neutral and line to ground on 277/480 V systems.
- G. Withstand Capabilities: 3000 Category C surges with less than 5 percent change in clamping voltage.
- H. Accessories:
1. Form-C contacts, one normally open and one normally closed, for remote monitoring of system operation. Contacts to reverse position on failure of any surge diversion module.
  2. Audible alarm activated on failure of any surge diversion module.
  3. Six-digit transient-counter set to total transient surges that deviate from the sine-wave envelope by more than 125 V.

## 2.04 OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker: NEMA AB 3, with interrupting capacity to meet available fault currents.
1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
  3. Electronic trip-unit circuit breakers shall have RMS sensing, field-replaceable rating plug, and the following field-adjustable settings:
    - a. Instantaneous trip.
    - b. Long- and short-time pickup levels.
    - c. Long- and short-time time adjustments.
    - d. Ground-fault pickup level, time delay, and  $I^2t$  response.
  4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
  5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
  6. GFCI Circuit Breakers: Single- and two-pole configurations with [5] [30]-mA trip sensitivity.
- B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.
1. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
  2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
  3. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
  4. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system, specified in Division 16 Section "Electrical Power Monitoring and Control."
  5. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
  6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
  7. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
  8. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
  9. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
- C. Enclosed, Insulated-Case Circuit Breaker: Fully rated, encased-power circuit breaker with interrupting capacity rating to meet available fault current.
1. Fixed circuit-breaker mounting.
  2. Two-step, stored-energy closing.
  3. Microprocessor-based trip units with interchangeable rating plug, LED trip indicators, and the following field-adjustable settings:
    - a. Instantaneous trip.
    - b. Long- and short-time pickup levels.
    - c. Long- and short-time time adjustments with  $I^2t$  response.
    - d. Ground-fault pickup level, time delay, and  $I^2t$  response.
  4. Remote trip indication and control.

5. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system specified in Division 16 Section "Electrical Power Monitoring and Control"
6. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
7. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.

## 2.05 INSTRUMENTATION

### A. Instrument Transformers: NEMA EI 21.1, IEEE C57.13, and the following:

1. Potential Transformers: Secondary voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
2. Current Transformers: Ratios shall be as indicated with accuracy class and burden suitable for connected relays, meters, and instruments.
3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kV.
4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondaries to ground overcurrent relays to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker ground-fault protection.

### B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
  - 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. Megawatts: Plus or minus 2 percent.
  - e. Megavars: Plus or minus 2 percent.
  - f. Power Factor: Plus or minus 2 percent.
  - g. Frequency: Plus or minus 0.5 percent.
  - h. Megawatt Demand: Plus or minus 2 percent; demand interval programmable from 5 to 60 minutes.
  - i. Accumulated Energy, Megawatt Hours: Plus or minus 2 percent. Accumulated values unaffected by power outages up to 72 hours.
2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

## 2.06 CONTROL POWER

- A. Control Circuits: 120 V, supplied through secondary disconnecting devices from control-power transformer.
- B. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
- C. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.07 ACCESSORY COMPONENTS AND FEATURES

- A. Furnish accessory set including tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- B. Furnish portable test set to test functions of solid-state trip devices without removal from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.
- C. Fungus Proofing: Permanent fungicidal treatment for switchboard interior, including instruments and instrument transformers.

PART 3 - EXECUTION

3.01 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

3.02 EXAMINATION

- A. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.03 INSTALLATION

- A. Install switchboards and accessories according to NEMA PB 2.1 and NECA 40.
- B. Install and anchor switchboards level on concrete bases, 4-inch nominal thickness. Concrete base is specified in Division 16 Section "Electrical Supports and Seismic Restraints," and concrete materials and installation requirements are specified in Division 3.
  - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
  - 2. For switchboards, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - 4. Install anchor bolts to elevations required for proper attachment to switchboards.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.
- D. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.
- E. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.
  - 1. Set field-adjustable switches and circuit-breaker trip ranges.

- F. Install spare-fuse cabinet.

### 3.04 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Section "Electrical Identification."
- B. Switchboard Nameplates: Label each switchboard compartment with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.
- C. Switchboard shall have Arc Flash warning labels.
- D. Switchboard shall have OSHA working clearance label.

### 3.05 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
  - 1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
  - 2. Test continuity of each circuit.
- B. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.
- C. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
- D. Perform the following field tests and inspections and prepare test reports:
  - 1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Sections 7.1, 7.5, 7.6, 7.9, 7.10, 7.11, and 7.14 as appropriate. Certify compliance with test parameters.
  - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
  - 3. Perform the following infrared scan tests and inspections and prepare reports:
    - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front panels so joints and connections are accessible to portable scanner.
    - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
    - c. Instruments, Equipment, and Reports:
      - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
      - 2) Prepare a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.06 CLEANING

- A. On completion of installation, inspect interior and exterior of switchboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

3.07 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories. Refer to Division 1 Section "Demonstration and Training." Owner shall have the option to videotape all demonstration and training sessions. Video equipment shall be provided by Owner.

END OF SECTION 16441



SECTION 16442

PANELBOARDS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following:
  - 1. Distribution panelboards.
  - 2. Lighting and appliance branch-circuit panelboards.

1.03 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground-fault circuit interrupter.
- C. RFI: Radio-frequency interference.
- D. RMS: Root mean square.
- E. SPDT: Single pole, double throw.

1.04 SUBMITTALS

- A. Product Data: For each type of panelboard, overcurrent protective device, accessory, and component indicated, include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each panelboard and related equipment:
  - 1. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings. Include the following:
    - a. Enclosure types and details for types other than NEMA 250, Type 1.
    - b. Bus configuration, current, and voltage ratings.
    - c. Short-circuit current rating of panelboards and overcurrent protective devices.
    - d. UL listing for full rating of installed devices.
    - e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
  - 2. Wiring Diagrams: Power, signal, and control wiring.
- C. Manufacturer Seismic Qualification Certification: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 16 Section 16072. Include the following:

1. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
    - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
  2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Qualification Data: For testing agency.
- E. Field quality-control test reports including the following:
1. Test procedures used.
  2. Test results that comply with requirements.
  3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- F. Panelboard Schedules: For installation in panelboards. Submit final typewritten versions after load balancing. Spare breaker locations shall be noted on schedule written in No. 2 pencil.
- G. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section, "Operation and Maintenance Data," include the following:
1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
  2. Time-current curves, including selectable ranges for each type of overcurrent protective device.
- 1.05 QUALITY ASSURANCE
- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the International Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
1. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.
- C. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories through one source from a single manufacturer.
- D. Product Options: Drawings indicate size, profiles, and dimensional requirements of panelboards and are based on the specific system indicated. Refer to Division 1 Section, "Product Requirements."

- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- F. Comply with NEMA PB 1.
- G. Comply with NFPA 70.

#### 1.06 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
  - 1. Ambient Temperature: Not exceeding 104 deg F.
  - 2. Altitude: Not exceeding 6600 feet
- B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
  - 1. Ambient temperatures within limits specified.
  - 2. Altitude not exceeding 6600 feet
- C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
  - 1. Notify Construction Manager and Owner no fewer than two days in advance of proposed interruption of electrical service.
  - 2. Do not proceed with interruption of electrical service without Construction Manager's and Owner's written permission.

#### 1.07 COORDINATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, and encumbrances to workspace clearance requirements.

#### 1.08 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Keys: Six spares for each type of panelboard cabinet lock. Keys shall be labeled with associated panel name.

### PART 2 - PRODUCTS

#### 2.01 MANUFACTURERS

- A. Manufacturer: Subject to compliance with requirements, provide products by the following:
  - 1. Panelboards, Overcurrent Protective Devices, Controllers, Contactors, and Accessories:
    - a. Square D.
    - b. General Electric

2.02 MANUFACTURED UNITS

- A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Division 16 Section 16072.
- B. Enclosures: Flush- and surface-mounted cabinets, as indicated. NEMA PB 1, Type 1.
  - 1. Rated for environmental conditions at installed location.
    - a. General, dry, dustless locations: NEMA 250, Type 1
  - 2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
  - 3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
  - 4. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
  - 5. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure, integral with enclosure body. Arrange to isolate individual panel sections.
  - 6. Finish: Manufacturer's standard enamel finish over corrosion-resistant treatment or primer coat.
  - 7. Directory Card: With transparent protective cover, mounted in metal frame, inside panelboard door.
- C. Phase and Ground Buses:
  - 1. Material: Hard-drawn copper, 98 percent conductivity.
  - 2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors, bonded to box.
  - 3. Isolated Equipment Ground Bus: Adequate for branch-circuit equipment ground conductors, insulated from box.
  - 4. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.
- D. Conductor Connectors: Suitable for use with conductor material.
  - 1. Main and Neutral Lugs: Compression type.
  - 2. Ground Lugs and Bus Configured Terminators: Compression type.
  - 3. Feed-Through Lugs: Compression type suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
  - 4. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.
- E. Future Devices: Mounting brackets, bus connections, and necessary appurtenances required for future installation of devices.

2.03 PANELBOARD SHORT-CIRCUIT RATING

- A. Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.04 DISTRIBUTION PANELBOARDS

- A. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
- B. Main Overcurrent Protective Devices: Circuit breaker.
- C. Branch Overcurrent Protective Devices:

1. For Circuit Breaker Frame Sizes 125A and Smaller: Bolt-on circuit breakers.
2. For Circuit-Breaker Frame Sizes Larger Than 125A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.
3. Fused switches.

## 2.05 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- B. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

## 2.06 OVERCURRENT PROTECTIVE DEVICES

- A. Molded Case Circuit Breaker: UL 489, with interrupting capacity to meet available fault currents.
  1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250A and larger.
  2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
  3. Electronic trip-unit circuit breakers shall have RMS sensing; field-replaceable rating plug; and with the following field-adjustable settings:
    - a. Instantaneous trip.
    - b. Long- and short-time pickup levels.
    - c. Long- and short-time time adjustments.
    - d. Ground-fault pickup level, time delay, and  $I^2t$  response.
  4. Current-Limiting Circuit Breakers: Frame sizes 400A and smaller; let-through ratings less than NEMA FU 1, RK-5.
  5. GFCI Circuit Breakers: Single- and two-pole configurations with 30mA trip sensitivity.
- B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.
  1. Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.
  2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air conditioning, and refrigerating equipment.
  3. Ground Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground fault indicator.
  4. Shunt Trip: 120V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
  5. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
  6. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
  7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
  8. Zone-Selective Interlocking: Integral with electronic trip unit for interlocking ground-fault protection function.
  9. Multipole units enclosed in a single housing or factory-assembled to operate as a single unit.

2.07 ACCESSORY COMPONENTS AND FEATURES

- A. Furnish accessory set including tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- B. Furnish portable test set to test functions of solid-state trip devices without removal from panelboard.
- C. Fungus Proofing: Permanent fungicidal treatment for panelboard interior, including overcurrent protective devices and other components.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install panelboards and accessories according to NEMA PB 1.1.
- B. Comply with mounting and anchoring requirements specified in Division 16 Section 16072.
- C. Mount top of trim 74 inches above finished floor, unless otherwise indicated.
- D. Mount plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.
- E. Install overcurrent protective devices and controllers.
  - 1. Set field-adjustable switches and circuit-breaker trip ranges.
- F. Install filler plates in unused spaces.
- G. Stub two 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub two 1-inch empty conduits into raised floor space or below slab not on grade.
- H. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

3.02 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Sections 16050, "Basic Electrical Methods" and 16075, "Electrical Identification."
- B. Create a directory to indicate installed circuit loads after balancing panelboard loads. Obtain approval before installing. Use a computer or typewriter to create directory; Spare breakers shall be indicated on schedule written with No. 2 pencil.
- C. Panelboard Nameplates: Label each panelboard with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.
- D. Panelboard cover shall have Arc Flash Warning Label.
- E. Panelboard cover shall have OSHA working clearance label.

3.03 CONNECTIONS

- A. Ground equipment according to Division 16 Section 16060, "Grounding and Bonding."
- B. Connect wiring according to Division 16 Section 16120, "Conduit and Cables."

3.04 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
  2. Test continuity of each circuit.
- B. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
  2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
1. Measure as directed during period of normal system loading.
  2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
  3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
  4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.
- D. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scanning of each panelboard. Remove panel fronts so joints and connections are accessible to portable scanner.
1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
  2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
  3. Record of Infrared Scanning: Prepare a certified report that identifies panelboards checked and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.05 CLEANING

- A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 16442

SECTION 16461

DRY TYPE TRANSFORMERS (600 V AND LESS)

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following types of dry type transformers rated 600 V and less, with capacities up to 1000 kVA:
  - 1. Distribution transformers.
  - 2. Control and signal transformers.

1.03 SUBMITTALS

- A. Product Data Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.
- B. Shop Drawings: Wiring and connection diagrams.
- C. Manufacturer Seismic Qualification Certification: Submit certification that transformer assembly and components will withstand seismic forces defined in Division 16 Section 16072. Include the following:
  - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
    - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
  - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Source quality-control test reports.
- E. Output Settings Reports: Record of tap adjustments specified in Part 3.

1.04 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with IEEE C 57.12.91.



1.05 DELIVERY, STORAGE, AND HANDLING

- A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.06 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.
- B. Coordinate installation of wall-mounting and structure-hanging supports.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Square D/Groupe Schneider NA.
  - 2. General Electric

2.02 MATERIALS

- A. Description: Factory-assembled and -tested, air-cooled units for 60 Hz service.
- B. Cores: Grain-oriented, non-aging silicon steel.
- C. Coils: Continuous windings without splices, except for taps.
  - 1. Internal Coil Connections: Brazed or pressure type.
  - 2. Coil Material: Copper.

2.03 DISTRIBUTION TRANSFORMERS

- A. Comply with NEMA ST 20, and list and label as complying with UL 1561.
- B. Provide transformers that are internally braced to withstand seismic forces specified in Division 16 Section 16072.
- C. Cores: One leg per phase.
- D. Enclosure: Ventilated, NEMA 250, Type 2.
- E. Indoor Transformer Enclosure Finish: Comply with NEMA 250 for "Indoor Corrosion Protection."
  - 1. Finish Color: Gray
- F. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 150 deg C rise above 40 deg C ambient temperature.
- G. Taps for Transformers Smaller Than 3 kVA: none

- H. Taps for Transformers 5kVA to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.
- I. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.
- J. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.
  - 1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
  - 2. Indicate value of K-factor on transformer nameplate.
- K. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.
  - 1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
  - 2. Include special terminal for grounding the shield.
  - 3. Shield Effectiveness:
    - a. Capacitance between Primary and Secondary Windings: Not to exceed 33 picofarads over a frequency range of 20 Hz to 1 MHz.
    - b. Common-Mode Noise Attenuation: Minus 120 dBA minimum at 0.5 to 1.5 kHz; minus 65 dBA minimum at 1.5 to 100 kHz.
    - c. Normal-Mode Noise Attenuation: Minus 52 dBA minimum at 1.5 to 10 kHz.
- L. Wall Brackets: Manufacturer's standard brackets.
- M. Fungus Proofing: Permanent fungicidal treatment for coil and core for transformers located in wet or damp environments.
- N. Low-Sound-Level Requirements: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

#### 2.04 CONTROL AND SIGNAL TRANSFORMERS

- A. Description: Self-cooled, two-winding dry type, rated for continuous duty, complying with NEMA ST 1, and listed and labeled as complying with UL 506.
- B. Ratings: Continuous duty. If rating is not indicated, provide at least 50 percent spare capacity above connected peak load.

#### 2.05 SOURCE QUALITY CONTROL

- A. Test and inspect transformers according to IEEE C57.12.91.
- B. Factory Sound-Level Tests: Conduct sound-level tests on equipment for this Project.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.
- B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.
- C. Examine walls and floors for suitable mounting conditions where transformers will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.
  - 1. Brace wall-mounting transformers as specified in Division 16 Section 16072.
- B. Install floor-mounting transformers level on concrete bases
- C. If appropriate, retain below for projects in areas of seismic activity.
  - 1. Anchor transformers to concrete bases according to manufacturer's written instructions, seismic codes at Project, and requirements in Division 16 Section 16072.

3.03 CONNECTIONS

- A. Ground equipment according to Division 16 Section 16060, "Grounding and Bonding."
- B. Connect wiring according to Division 16 Section 16120, "Conduit and Cables."
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.04 ADJUSTING

- A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 5 percent. Submit recording and tap settings as test results.
- B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

END OF SECTION 16461

SECTION 16491

FUSES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following:

1. Cartridge fuses rated 600V and less for use in disconnect switches, panelboards, switchboards, and motor controllers.
2. Spare-fuse cabinets.

1.03 SUBMITTALS

- A. Product Data: Include the following for each fuse type indicated:

1. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
2. Let-through current curves for fuses with current-limiting characteristics.
3. Time-current curves, coordination charts and tables, and related data.
4. Fuse size for elevator feeders and elevator disconnect switches.

- B. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.

1. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
2. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.

- C. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Division 1 Section "Closeout Procedures," include the following:
  - a. Let-through current curves for fuses with current-limiting characteristics.
  - b. Time-current curves, coordination charts and tables, and related data.
  - c. Ambient temperature adjustment information.

1.04 QUALITY ASSURANCE

- A. Source Limitations: Obtain fuses from a single manufacturer.

- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

- C. Comply with NEMA FU 1.
- D. Comply with NFPA 70.

1.05 PROJECT CONDITIONS

- A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.06 COORDINATION

- A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size.

1.07 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Fuses: Quantity equal to 10 percent of each fuse type and size, but no fewer than six of each type and size.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Cooper Bussman, Inc.
  - 2. Eagle Electric Mfg. Co., Inc.; Cooper Industries, Inc.
  - 3. Ferraz Shawmut, Inc.
  - 4. Tracor, Inc.; Littelfuse, Inc. Subsidiary.

2.02 CARTRIDGE FUSES

- A. Characteristics: NEMA FU 1, nonrenewable cartridge fuse; class and current rating indicated; voltage rating consistent with circuit voltage.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- B. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 FUSE APPLICATIONS

- A. Service Entrance: Class L, fast acting; L, time delay; RK1, fast acting; RK1, time delay; J, fast acting; J, time delay; T, fast acting.

- B. Feeders: Class L, fast acting; L, time delay; RK1, fast acting; RK1, time delay; J, fast acting; J, time delay; T, fast acting.
- C. Motor Branch Circuits: Class RK1 time delay.
- D. Other Branch Circuits: Class RK1, time delay; J, fast acting; J, time delay.

3.03 INSTALLATION

- A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.
- B. Install spare-fuse cabinet(s).

3.04 IDENTIFICATION

- A. Install labels indicating fuse replacement information on inside door of each fused switch.

END OF SECTION 16491

SECTION 16511

INTERIOR LIGHTING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following:

1. Interior lighting fixtures with lamps and ballasts.
2. Lighting fixtures mounted on exterior building surfaces.
3. Emergency lighting units.
4. Exit signs.

- B. Related Sections include the following:

1. Division 16 Section 16140, "Wiring Devices" for manual wall-box dimmers for incandescent lamps.

1.03 DEFINITIONS

- A. BF: Ballast factor. Ratio of light output of a given lamp(s) operated by the subject ballast to the light output of the same lamp(s) when operated on an ANSI reference circuit.

- B. CRI: Color rendering index.

- C. CU: Coefficient of utilization.

- D. LER: Luminaire efficiency rating, which is calculated according to NEMA LE 5. This value can be estimated from photometric data using the following formula:

1. LER is equal to the product of total rated lamp lumens times BF times luminaire efficiency, divided by input watts.

- E. RCR: Room cavity ratio.

1.04 SUBMITTALS

- A. Product Data: For each type of lighting fixture scheduled, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:

1. Physical description of fixture, including dimensions and verification of indicated parameters.
2. Emergency lighting unit battery and charger.
3. Fluorescent ballasts.
4. Air and Thermal Performance Data: For air-handling fixtures. Furnish data required in "Submittals" Article in Division 15 Section, "Diffusers, Registers, and Grilles."

5. Sound Performance Data: For air-handling fixtures. Indicate sound power level and sound transmission class in test reports certified according to standards specified in Division 15 Section, "Diffusers, Registers and Grilles."
  6. Lamps.
- B. Shop Drawings: Show details of nonstandard or custom fixtures. Indicate dimensions, weights, methods of field assembly, components, features, and accessories.
- C. Wiring Diagrams: Power, signal, and control wiring.
- D. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
1. Suspended ceiling components.
  2. Structural members to which lighting-fixture suspension systems will be attached.
  3. Other items in finished ceiling, including the following:
    - a. Air outlets and inlets.
    - b. Speakers.
    - c. Sprinklers.
    - d. Access panels.
  4. Perimeter moldings.
- E. Samples for Verification: For interior lighting fixtures designated for sample submission in the Interior Lighting Fixture Schedule.
1. Lamps: Specified units installed.
  2. Ballast: 120V models of specified ballast types.
  3. Accessories: Cords and plugs.
- F. Product Certificates: For each type of ballast for dimmer-controlled fixtures, signed by product manufacturer.
- G. Source quality-control test reports.
- H. Field quality-control test reports.
- I. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section, "Operation and Maintenance Data," include the following:
1. Catalog data for each fixture. Include the diffuser, ballast, and lamps installed in that fixture.
- J. Warranties: Special warranties specified in this Section.



1.05 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the International Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
  - 1. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with NFPA 70.
- E. FMG Compliance: Fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FMG.
- F. NFPA 101 Compliance: Comply with visibility and luminance requirements for exit signs.

1.06 COORDINATION

- A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.07 WARRANTY

- A. Special Warranty for Emergency Lighting Unit Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period: Ten years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining nine years.
- B. Special Warranty for Fluorescent Ballasts: Manufacturer's standard form in which ballast manufacturer agrees to repair or replace ballasts that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period for Electronic Ballasts: Five years from date of Substantial Completion.
  - 2. Warranty Period for Electromagnetic Ballasts: Three years from date of Substantial Completion.
- C. Manufacturer's Special Warranty for T8 Fluorescent Lamps: Manufacturer's standard form, made out to Owner and signed by lamp manufacturer agreeing to replace lamps that fail in materials or workmanship, f.o.b. the nearest shipping point to Project site, within specified warranty period indicated below.
  - 1. Warranty Period: Two years from date of Substantial Completion.

1.08 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
  2. Plastic Diffusers and Lenses: 5 for every 100 of each type and rating installed. Furnish at least one of each type.
  3. Battery and Charger Data: One for each emergency lighting unit.
  4. Ballasts: Five for every 100 of each type and rating installed. Furnish at least one of each type.
  5. Globes and Guards: 1 for every 20 of each type and rating installed. Furnish at least one of each type.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2.02 FIXTURES AND COMPONENTS, GENERAL

- A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.
- B. Incandescent Fixtures: Comply with UL 1571 and 1598. Where LER is specified, test according to NEMA LE 5A.
- C. Fluorescent Fixtures: Comply with UL 1570 and 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.
- D. HID Fixtures: Comply with UL 1572 and 1598. Where LER is specified, test according to NEMA LE 5B.
- E. Metal Parts: Free of burrs and sharp corners and edges.
- F. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.
- G. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
- H. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:
1. White Surfaces: 85 percent.
  2. Specular Surfaces: 83 percent.
  3. Diffusing Specular Surfaces: 75 percent.
  4. Laminated Silver Metallized Film: 90 percent.

I. Plastic Diffusers, Covers, and Globes:

1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
  - a. Lens Thickness: At least 0.125 inches minimum unless different thickness is scheduled.
  - b. UV stabilized.
2. Glass: Annealed crystal glass, unless otherwise indicated.

2.03 LIGHTING FIXTURES

- A. Fixtures to be as designated on the drawings in the Light Fixture Schedule.

2.04 FLUORESCENT LAMP BALLASTS

- A. Description: Include the following features, unless otherwise indicated:

1. Designed for type and quantity of lamps indicated at full light output except for emergency lamps powered by in-fixture battery-packs.
2. Externally fused with slow-blow type rated between 2.65 and 3.0 times the line current.

- B. Electronic ballasts for linear lamps shall include the following features, unless otherwise indicated:

1. Comply with NEMA C82.11.
2. Ballast Type: Rapid start, unless otherwise indicated.
3. Programmed Start: Ballasts with two-step lamp starting to extend life of frequently started lamps.
4. Sound Rating: A
5. Total harmonic distortion rating of less than 10 percent according to NEMA C82.11.
6. Transient Voltage Protection: IEEE C62.41, Category A.
7. Operating Frequency: 20kHz or higher.
8. Lamp Current Crest Factor: Less than 1.7
9. Parallel Lamp Circuits: Multiple lamp ballasts connected to maintain full light output on surviving lamps if one or more lamps fail.

- C. Electromagnetic ballasts for linear lamps shall have the following features, unless otherwise indicated:

1. Comply with NEMA C82.1.
2. Type: Energy-saving, high power factor, Class P, automatic-reset thermal protection.
3. Ballast Manufacturer Certification: Indicated by label.
4. Provide lamp end-of-life detection and shutdown circuit for T5 diameter lamps.

- D. Ballasts for compact lamps in recessed fixtures shall have the following features, unless otherwise indicated:

1. Type: Electronic or electromagnetic, as specified
2. Power Factor: 90 percent, minimum.
3. Flicker: Less than 5 percent.
4. Lamp Current Crest Factor: Less than 1.7
5. Electronic Ballast Operating Frequency: 20kHz or higher.
6. Lamp end-of-life detection and shutdown circuit.

7. Transient Protection: Comply with IEEE C62.41 for Category A1 locations.
  8. Interference: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.
- E. Ballasts for compact lamps in nonrecessed fixtures shall include the following features, unless otherwise indicated:
1. Power Factor: 90 percent, minimum.
  2. Ballast Coil Temperature: 65 deg C, maximum.
  3. Transient Protection: Comply with IEEE C62.41 for Category A1 locations.
  4. Interference: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.
- F. Ballasts for Low-Temperature Environments:
1. Temperatures 0 deg F and Higher: Electronic or electromagnetic type rated for 0 deg F starting temperature.
  2. Temperatures Minus 20 deg F and Higher: Electromagnetic type designed for use with high-output lamps.
- G. Ballasts for Low Electromagnetic-Interference Environments: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for consumer equipment.

## 2.05 EXIT SIGNS

- A. General: Comply with UL 924; for sign colors and lettering size, comply with authorities having jurisdiction.
- B. Exit signs shall be green led with brushed aluminum face in black housing.
- C. Internally Lighted Signs:
1. Lamps for AC Operation: Light-emitting diodes, 70,000 hours minimum of rated lamp life.
  2. Additional Lamps for DC Operation: Two minimum, bayonet-base type, for connection to external dc source.

## 2.06 FLUORESCENT EMERGENCY LIGHTING FIXTURES

- A. Internal Type: Self-contained, modular, battery-inverter unit factory mounted within fixture body. Comply with UL 924.
1. Emergency Connection: Operate one fluorescent lamp continuously. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.
  2. Night Light Connection: Operate one fluorescent lamp continuously.
  3. Test Switch and Light-Emitting-Diode Indicator Light: Visible and accessible without opening fixture or entering ceiling space.
  4. Battery: Sealed, maintenance-free, nickel-cadmium type with minimum seven-year nominal life.
  5. Charger: Fully automatic, solid-state, constant-current type.
- B. External Type: Self-contained, modular, battery-inverter unit, suitable for powering one or more fluorescent lamps, remote mounted from light fixture. Comply with UL 924.

1. Emergency Connection: Operate one fluorescent lamp continuously. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.
2. Night Light Connection: Operate one fluorescent lamp in a remote fixture continuously.
3. Battery: Sealed, maintenance-free, nickel-cadmium type with minimum seven-year nominal life.
4. Charger: Fully automatic, solid-state, constant-current type.
5. Housing: NEMA 250, Class 1 enclosure.

## 2.07 FLUORESCENT LAMPS

- A. Low-Mercury Lamps: Comply with Federal toxic characteristic leaching procedure test, and yield less than 0.2 mg of mercury per liter, when tested according to NEMA LL 1.
- B. T8 rapid-start low-mercury lamps, rated 32 W maximum, 2800 initial lumens (minimum), CRI of 75 (minimum), color temperature of 3500 K, and average rated life of 20,000 hours, unless otherwise indicated.
- C. T8 rapid-start low-mercury lamps, rated 17 W maximum, nominal length of 24 inches, 1300 initial lumens (minimum), CRI of 75 (minimum), color temperature of 3500 K, and average rated life of 20,000 hours, unless otherwise indicated.
- D. Compact Fluorescent Lamps: CRI 80 (minimum), color temperature 3500 K, average rated life of 10,000 hours at 3 hours operation per start, unless otherwise indicated.
  1. T4, Twin Tube: Rated 5 W, 250 initial lumens (minimum).
  2. T4, Twin Tube: Rated 7 W, 400 initial lumens (minimum).
  3. T4, Twin Tube: Rated 9 W, 600 initial lumens (minimum).
  4. T4, Twin Tube: Rated 13 W, 825 initial lumens (minimum).
  5. T4, Double-Twin Tube: Rated 13 W, 900 initial lumens (minimum).
  6. T4, Double-Twin Tube: Rated 18 W, 1200 initial lumens (minimum).
  7. T4, Double-Twin Tube: Rated 26 W, 1800 initial lumens (minimum).

## 2.08 FIXTURE SUPPORT COMPONENTS

- A. Comply with Division 16 Section 16050, "Basic Electrical Methods" for channel- and angle-iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.
- C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.
- D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated, 12 AWG or as specified.
- E. Wires For Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 AWG or as specified.
- F. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.
- G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.
- H. Aircraft Cable Support: Use cable, anchorages, and intermediate supports recommended by fixture manufacturer.

2.09 FINISHES

- A. Fixtures: Manufacturers' standard, unless otherwise indicated.
  - 1. Paint Finish: Applied over corrosion-resistant treatment or primer, free of defects.
  - 2. Metallic Finish: Corrosion resistant.

2.10 SOURCE QUALITY CONTROL

- A. Provide services of a qualified, independent testing and inspecting agency to factory test fixtures with ballasts and lamps; certify results for electrical ratings and photometric data.
- B. Factory test fixtures with ballasts and lamps; certify results for electrical ratings and photometric data.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.
- B. Support for Fixtures in or on Grid-Type Suspended Ceilings: Use grid for support.
  - 1. Install a minimum of four ceiling support system rods or wires for each fixture. Locate not more than 6 inches from fixture corners.
  - 2. Support Clips: Fasten to fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
  - 3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.
  - 4. Install at least one independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.
- C. Suspended Fixture Support: As follows:
  - 1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
  - 2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
  - 3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
  - 4. Continuous Rows: Suspend from cable.

3.02 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.03 FIELD QUALITY CONTROL

- A. Inspect each installed fixture for damage. Replace damaged fixtures and components.
- B. Verify normal operation of each fixture after installation.
- C. Test for Emergency Lighting: Interrupt power supply for 1.5 hours to demonstrate proper operation. Verify normal transfer to battery power source and retransfer to normal.

- D. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.
- E. Corroded Fixtures: During warranty period, replace fixtures that show any signs of corrosion.

END OF SECTION 16511