

# **CONSTRUCTION MANUAL PART 3**



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### Introduction to Guideline Specifications

The LPS Guideline Specifications (LPSCM - Part 1) provide general direction to Architects and other Consultants for the design and specification of District facilities and facility improvements. They also identify for prospective vendors and contractors products and equipment pre-approved for conformance to District standards and expectations. They are intended to promote consistent quality and reasonable continuity in products, materials, systems and workmanship for all District facilities; they are not intended to limit creative design or functional problem-solving. **The Guidelines are not sufficiently complete to serve as buildable technical specifications**; any proposed deviation from them will require consultation with and acceptance by the LPS Operations, Maintenance and Construction Department (OMC). Consultants also will be responsible for informing the District of any conflict found between the Guidelines and current codes, standards or best practices.

### Introduction to Model Specifications & Technology Standards

The LPS Model Specifications (LPSCM - Parts 2 and 3) provide more detailed definition of District construction standards and procedures for consultants and contractors, based upon cumulative District experience with facility design, maintenance and operations. **Each section is intended to serve as a model for buildable technical specifications, typically requiring customization** to address conditions, needs and applications for specific projects at particular facilities through detailed collaboration between consultants and LPS managers, technicians and users. Identification of technical requirements or prohibitions, pre-approved manufacturers, and preferred products or models is intended to optimize long-term value to the District and its facilities, balancing innovation and competitive first-cost with manageable standardization and sustainable life-cycle costing.

The LPS Technology Standards (LPSCM – Part 4) provide definitive goals, design and installation mandates and detailed specifications for District facilities infrastructure and systems supporting Information Technology, Domestic and Emergency Communications, Smoke/Fire Detection and Alarm, and Building Access and Security. The Standards identify professional certifications for design engineers, manufacturer certifications for installers, and relevant experience required for both. Proprietary platforms are identified for each major

system, along with pre-approved providers of mutually compatible component devices. **Deviation from any provision in these Standards is prohibited except for unique circumstances and only following exhaustive review and sign-off by the LPS Operations, Maintenance and Construction Department (OMC), Information and Technology Services (ITS) and/or Security and Emergency Planning, as appropriate, via specific project programming and design. Construction drawings and Specifications based on these Standards must provide for complete, properly operating systems fully integrated into existing District central operations, monitoring and control.**

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**SECTION 26 05 00 - BASIC ELECTRICAL REQUIREMENTS****PART 1 - GENERAL:****1.1 RELATED DOCUMENTS:**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to work of this section and all subsequent Division 26 sections.

**1.2 SUMMARY:**

- A. This Section specifies the basic requirements for electrical installations and includes requirements common to more than one section of Division 26. It expands and supplements the requirements specified in sections of Divisions 2 through 28.

**1.3 ACCESSIBILITY:**

- A. Install equipment and materials to provide required code clearances and access for servicing and maintenance. Coordinate the final location with piping, ducts, and equipment of other trades to insure proper access for all trades. Coordinate locations of concealed equipment, disconnects, and boxes with access panels and doors. Allow ample space for removal of parts, fuses, lamps, etc. that require replacement or servicing.
- B. Extend all conduits so that junction and pull boxes are in accessible locations.
- C. Provide access panel or doors where equipment or boxes are concealed behind finished surfaces.

**1.4 ROUGH-IN:**

- A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.
- B. Refer to equipment specifications in Divisions 20 through 28 for rough-in requirements.

**1.5 REQUIREMENTS OF REGULATORY AGENCIES:**

- A. Execute and inspect all work in accordance with Underwriters Laboratories (UL) and all local and state codes, rules and regulations applicable to the trade affected as a minimum, but if the plans and/or specifications call for requirements that exceed these rules and regulations, the more stringent requirement shall be followed. Follow application sections and requirements and testing procedures of NFPA, IEEE, NEMA, CBM, ANSI, NECA, ICEA and NETA.

- B. Comply with standards in effect at the date of these Contract Documents, except where a standard or specific date or edition is indicated.
  - C. All material used on this project shall be UL listed and labeled and be acceptable to the Authority Having Jurisdiction as suitable for the use intended.
  - D. After entering into contract, Contractor will be held to complete all work necessary to meet these requirements without additional expense to the Owner.
- 1.6 REQUIREMENTS OF LOCAL UTILITY COMPANIES:
- A. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies and controlling agencies. Provide required connection for each service.
- 1.7 PERMITS AND FEES:
- A. Contractor shall pay all fees required for connection to municipal and public utility facilities.
  - B. Contractor shall arrange for and pay for all inspections, licenses and certificates required in connection with the work.
- 1.8 ELECTRICAL INSTALLATIONS:
- A. Drawings are diagrammatic in character and do not necessarily indicate every required conduit, box, fitting, etc.
  - B. Drawings and specifications are complementary. Whatever is called for in either is binding as though called for in both.
  - C. Drawings shall not be scaled for rough-in measurements or used as shop drawings. Where drawings are required for these purposes or have to be made from field measurement, take the necessary measurements and prepare the drawings.
  - D. Before any work is begun, determine that equipment will properly fit the space and that conduit can be run as contemplated without interferences between systems, with structural elements or with the work of other trades.
  - E. Coordinate the installation of electrical materials and equipment above and below ceilings with suspension system, luminaires and other building components. Ductwork and piping shall not be installed above electrical panelboards, switchboards, motor control centers, and transformers.



1. Coordinate ceiling cavity space carefully with all trades. In the event of conflict, space for mechanical and electric systems within the cavity shall be allocated in the following order:

Plumbing waste, vent piping and roof drain mains and leaders.

Supply, return and exhaust ductwork.

Fire sprinkler mains and leaders.

Electrical conduit.

Domestic hot and cold water.

Pneumatic control piping.

Fire sprinkler branch piping and sprinkler run-outs.

- F. Verify all dimensions by field measurements.
- G. Arrange for chases, slots, and openings in other building components to accommodate electrical installations.
- H. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.
- I. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the work. Give particular attention to large equipment requiring an access path for positioning prior to closing-in the building or space.
- J. Coordinate the cutting and patching of building components to accommodate the installation of electrical equipment and materials.
- K. Where mounting heights are not detailed or dimensioned, install electrical conduits, boxes, and overhead equipment to provide the maximum headroom possible. In general, keep installations tight to structure.
- L. Install electrical equipment to facilitate maintenance and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting and removal with minimum of interference with other installations.
- M. Installation shall comply with the local seismic requirements for the area of installation. Provide restraints, bracing, anchors, vibration isolation, seismic snubbers, and all other components required for the installation.

- N. All Journeymen shall be licensed, and all apprentices shall be registered with the State of Colorado electrical board. Licenses and registration shall be shown to LPS Operations, Maintenance and Construction (OMC) Department electricians upon request.
  - O. The contractor shall provide personnel with the ratio of Journeymen to Apprentices as mandated by the State of Colorado.
  - P. All equipment and materials installed shall be new unless otherwise specified. Existing equipment and materials shall be reused where indicated. All major equipment and components shall have the manufacture's name, address, model number and serial numbers permanently attached.
  - Q. Equipment and materials shall comply with the OMC Department's list of acceptable products. Any variation from this list requires written approval from the OMC Department.
  - R. Definitions: "Provide" shall mean "furnish and install", "Accept" or "Acceptable" indicates only that the item is in "general conformance" with the stated design concept for the project.
  - S. All penetrations through any wall, floor or roof for any reason shall be sleeved and fire caulked. See requirement of Section 07 80 00.
- 1.9 METHODS OF PROCEDURE (MOP):
- A. Definition: Method of Procedure (MOP) is a written plan which describes the activities and procedures to safeguard the building's occupants and contents and to interface with the building's management, operations and security. Building occupants shall be defined as employees, and visitors.
  - B. Requirements:
    - 1. A MOP is required when a construction activity affects the safety of the occupants, equipment or valuable contents, or any supporting system; or essentially affects the building's management, operations or security.
    - 2. A MOP is required for any shutdown or interruption of any system which affects the building occupants, including, but not limited to, infrastructure, life safety, electrical, and building management systems.

3. A MOP is required when requested or deemed necessary by the Owner or Engineer.

C. Development:

1. The Prime Contractor shall develop, submit, track and process the MOP. Any assistance required by the Subcontractors shall be provided. All MOP's shall be reviewed by the Prime Contractor prior to submitting the MOP to the Engineer.
2. All MOP's shall be typed.
3. Contractor shall develop the MOP in a timely fashion prior to review and approval by all required parties.
4. Contractor shall develop the MOP with input from the subcontractor(s), where necessary.

D. Form: Each MOP shall be a written document in narrative, descriptive or outline form supplemented with drawings, diagrams and schedules as necessary. The detailed format included in the appendix shall be utilized.

E. Review and Approval: Contractor shall submit each MOP to the Engineer for review and approval. All MOP's require Owner's approval.

F. Implementation: Contractor shall implement the MOP when approved by the Engineer and Owner in writing. No construction activity which requires a MOP shall proceed until the MOP is approved.

- G. Compliance: Contractor shall comply with the approved MOP. The Owner and Engineer reserve the right to stop the work for non-compliance with the MOP. Any cost or time delay resulting from the work stoppage shall be borne by the Contractor.
  
- H. Posting: Work shall not proceed on any facet of the work involving an MOP if an approved and signed MOP is not posted in the work area.

**1.10 ELECTRICAL COORDINATION DRAWINGS:**

- A. Prepare and submit a set of coordination drawings showing major elements, components, and systems of electrical equipment and materials in relationship with other building components. Prepare 11"x17" (min.) drawings to an accurate scale of 1/4"=1'-0" or larger. Indicate the locations of all equipment and materials, including clearances for servicing and maintaining equipment. Indicate movement and positioning of large equipment into the building during construction.
  
- B. Prepare floor plans, reflected ceiling plans, elevations, sections, and details to conclusively coordinate and integrate all installations. Indicate locations where space is limited, and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:
  - 1. Electric equipment room layouts
  - 2. Mechanical equipment room layouts
  
- C. Prepare coordination drawings for specific equipment installations, including but not limited to the following:
  - 1. Cable Tray
  - 2. Switchgear
  - 3. Motor control centers
  - 4. Generators and automatic transfer switches
  - 5. Pad mounted and/or dry type transformers
  - 6. Switchboards and panelboards
  - 7. Equipment connections
  - 8. Control panels

- 9. Circuit and motor disconnects
- 10. Feeder conduits

D. Wiring Diagrams: Provide wiring diagrams indicating field-installed electrical power and control wiring and cabling layouts, overcurrent protective devices, equipment and equipment connections.

#### 1.11 EQUIPMENT HOUSEKEEPING PADS:

A. Provide 4" concrete housekeeping pad for all floor mounted equipment including, but not limited to: switchgear, switchboards, motor control centers, floor mounted distribution panelboards, floor mounted branch panelboards, and floor mounted dry type transformers. Fabricate pads as follows:

1. Coordinate size of equipment bases with actual unit sizes provided. Fabricate base 4" larger in both directions than the overall dimensions of the supported unit.
2. Form concrete pads with framing lumber with form release compounds. Chamfer top edge and corners of pad.
3. Place concrete and allow curing before installation of units. Use Portland cement that conforms to ASTM C 150, 4000-psi compressive strength, and normal weight aggregate.
4. Anchor housekeeping pads to slab using #3 rebar bent in "L" or "Z" shape 12 inch on center on each side of slab.

#### 1.12 EXCAVATING AND BACKFILLING:

A. General:

1. Provide all necessary excavation and backfill for installation of electrical work in accordance with Divisions 2 and 31.
2. In general, follow all regulations of OSHA as specified in Part 1926, Subpart P, "Excavations, Trenching and Shoring." Follow specifications of Division 26 as they refer specifically to the electrical work.

B. Contact Owners of all underground utilities to have them located and marked, at least 2 business days before excavation is to begin. Prior to starting excavation, brief employees on markings and color codes, and train employees on excavation and safety procedures for natural gas lines. When excavation approaches gas lines, expose lines by carefully probing and hand digging.

- C. Backfilling shall not be started until all work has been inspected, tested and accepted. All backfill material shall be accepted by the soils engineer. In no case shall lumber, metal or other debris be buried in with backfill.
- D. Trench Backfill
  - 1. Backfill to 4 inches above top of conduits with sand, the same as used for conduit bed, and compact properly.
  - 2. Continue backfill to finish grade, using friable material free of rock and other debris. Install in 6 inch layers, each properly moistened and mechanically compacted prior to installation of ensuing layer. Compaction by hydraulic jetting is not permissible.
- E. After backfilling and compacting, any settling shall be refilled, tamped, and refinished at contractor's expense.
- F. This contractor shall repair and pay for any damage to finished surfaces.
- G. Backfill near manholes or hand holes using sand, installing it in 6 inch layers to 4 inches above the shallowest conduit. Use suitable excavated material to complete the backfill, installed in 6 inch layers and mechanically compacted to seal against water infiltration. Compact to 95% below paving and slabs and to 90% elsewhere.

#### 1.13 CUTTING AND PATCHING:

- A. This Article specifies the cutting and patching of electrical equipment, components, and materials to include removal and legal disposal of selected materials, components, and equipment.
- B. Refer to Divisions 2 and 31 sections covering cutting and patching for general requirements.
- C. Do not endanger or damage installed Work through procedures and processes of cutting and patching.
- D. When coring is required or identified, an x-ray of the area is to be taken prior to the performance of the work operation. X-ray work requires an MOP and protection.
- E. Arrange for repairs required to restore other work, because of damage caused as a result of electrical installations.
- F. No additional compensation will be authorized for cutting and patching Work that is necessitated by ill-timed, defective, or non-conforming installations.

1. Perform cutting, fitting, and patching of electrical equipment and materials required to:
    - a. Uncover Work to provide for installation of ill-timed Work;
    - b. Remove and replace defective Work;
    - c. Remove and replace Work not conforming to requirements of the Contract Documents;
    - d. Remove samples of installed Work as specified for testing;
    - e. Install equipment and materials in existing structures;
  2. Upon written instructions from the Architect/Engineer, uncover and restore Work to provide for Architect/Engineer observation of concealed Work.
- G. Cut, remove and legally dispose of selected electrical equipment, components, and materials as indicated, including, but not limited to removal of conductors, conduit, luminaires, boxes, devices and other electrical items made obsolete by the new Work.
- H. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.
- I. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.
- J. Locate identify, and protect mechanical and electrical services passing through remodel or demolition area and serving other areas required to be maintained operational.
- 1.14 TEMPORARY FACILITIES:
- A. Light, Heat, Power, Etc.
1. Responsibility for providing temporary electricity, heat and other facilities shall be as identified in these specifications, as shown on drawings and as specified in the General Conditions of the Contract and in Division 2 and other Division 26 sections.
- B. Building distribution equipment and devices (existing or new) shall not be used without written permission of the Owner. If used for temporary power, the equipment shall be properly maintained and any damage resulting from use shall be repaired by the Contractor. The warranty period for new equipment shall begin at the date of Final Completion.
- C. If AC power systems or their backup systems serving telecommunications, computer equipment, or their associated HVAC equipment and controls are taken out of service,

for any reason, the Contractor shall be responsible for providing temporary systems during the period when the AC power systems or their backup systems are out of service. The Contractor shall be responsible for providing temporary power to all loads being interrupted.

**1.15 ELECTRICAL SUBMITTALS:**

- A. Refer to the Conditions of the Contract (General and Supplementary) and other Division 26 sections covering shop drawings, product data, and samples for submittal definitions, requirements, and procedures.
- B. The manufacturer's material or equipment listed first in the specifications or on the drawings are the types to be provided for the establishment of size, capacity, grade and quality. If alternates are used in lieu of the first names, the cost of any changes in construction required by their use shall be borne by this Contractor.
- C. All equipment shall conform to the State and/or local Energy Conservation Standards.
- D. Submittal of shop drawings, product data, and samples will be accepted only when submitted by the Contractor. Each submittal shall be reviewed for general conformance with contract requirements and stamped by the respective contractor prior to submittal to the Architect/Engineer. Data submitted from subcontractors and material suppliers directly to the Architect/Engineer will not be processed unless written prior approval is obtained by the Contractor.
- E. Before starting work, prepare and submit to the Architect/Engineer two (2) sets of all shop drawings, descriptive product data, and samples required for the project. Continue to submit two (2) sets, after each Architect/Engineer's action, until a "No Exception Taken" or "Make Correction Noted" action is received. Submittals shall include the following specified materials and, in addition, any materials not listed below but which are specified in the individual sections of Division 26 and other referenced Divisions that follow.
  - 1. Raceways including surface raceways and wireways.
  - 2. Cable trays or bridle ring assemblies.
  - 3. Cabinets, boxes, fittings, etc.
  - 4. Wiring devices, including tele/data/power poles.
  - 5. Electrical equipment signs and labels.
  - 6. Switchboards
  - 7. Grounding



8. Transformers
  9. Panelboards
  10. Disconnect Switches
  11. Circuit breakers and fused switches for installation in existing panelboards or distribution centers.
  12. Motor control including motor control centers and individual manual and magnetic starters provided under this Division.
  13. Automatic and manual transfer switches including all ancillary equipment.
  14. Poles and Standards.
  15. Lighting
  16. Emergency power supplies including unit type equipment.
  17. Engine generator including transfer switches and all ancillary equipment.
  18. Fire alarm and detection system.
  19. Paging and background music system.
  20. Intercom system.
  21. Lighting control system including individual wall dimmers.
- F. Submit proposed changes to electrical room or other equipment room layouts when revised from contract documents prior to installation.
- G. Mark submittals with designations as shown on the drawings and identify as required by Specification Sections. Identification shall contain the information as required in details, and each label shall be submitted in list form with disconnects, MCC's, panelboards, switchboards, overcurrent protection devices and utilization equipment.
- H. All electrical submittals shall be assembled into a single package after approval of all sections.
1. Submittals shall be provided in expandable, three-ring, hard back binders.
  2. Each submittal shall be tabbed by the electrical specification section it is specified in.
  3. An index shall be provided which includes:

- a. Product
  - b. Plan Code (if applicable)
  - c. Specification Section
  - d. Manufacturer and Model Number
4. Submittals shall be provided for review within four (4) weeks from award of contract to successful bidder.

**1.16 PRODUCT OPTIONS AND SUBSTITUTIONS:**

- A. The burden of proof that proposed equipment is equal in size, capacity, performance, and other pertinent criteria for this specific installation, or superior to that specified is up to the Contractor. Substituted equipment will only be allowed where specifically listed in a written addendum. If substitutions are not granted, the specified materials and equipment must be installed. Where substituted equipment is allowed, it shall be the Contractor's responsibility to notify all related trades of the accepted substitution and to assume full responsibility for all costs caused as a result of the substitution.
- B. Unless otherwise specified, all materials and equipment shall be of domestic (USA) manufacture.

**1.17 PRODUCT LISTING:**

- A. Prepare a list of major electrical equipment and materials for the project. A sample schedule is included at the end of this Section to complete this requirement.
- B. Provide a complete product listing within four (4) weeks from award of contract to successful bidder.
- C. Submit this listing as a part of the submittal requirements specified in the General Conditions of the Contract regarding Products and Substitutions.
- D. When two or more items of same material or equipment are required they shall be of the same manufacturer. Product manufacturer uniformity does not apply to raw materials, bulk materials, sheet metal, steel bar stock, welding rods, solder, fasteners and similar items used in Work, except as otherwise indicated.
- E. For conduit, wire and fittings, the Contractor shall select a prime and alternate manufacturer from the list of acceptable manufacturers provided in the appropriate sections of this Division. The prime and alternate manufacturers shall be identified in the product listing. The contractor shall make every effort to use the prime manufacturer for

the entire project. If products from this manufacturer are unavailable, the Contractor shall use the listed alternate with the following provisions.

1. Wire: All wire placed in a single conduit or installed in multiple conduits making up parallel feeders shall be of the same manufacturer.
2. Conduit and Fittings: All conduits and fittings installed exposed within the same room or immediate area shall be of the same manufacturer.

F. Provide products which are compatible within systems and other connected items.

#### 1.18 SCHEDULE OF VALUES:

A. Provide preliminary schedule of values to Engineer according to the following descriptions:

1. Demolition
2. Service/Distribution
3. Lighting - Interior
4. Lighting - Exterior
5. Basic Materials/Devices/Equipment Connections (Mechanical)
6. Emergency Generator
7. Fire Alarm (Material/Installation)
8. Building F.A. System
9. P.A./Sound/Intercom
10. Miscellaneous

B. Provide Preliminary Schedule of Values to Engineer with product data submittal or within four (4) weeks from award of contract, whichever is earliest.

#### 1.19 NAMEPLATE DATA:

A. Provide equipment with permanent operational data nameplate on each item of power operated equipment, indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data. Install equipment so that nameplate is readily visible.

**1.20 DELIVERY, STORAGE AND HANDLING:**

- A. Refer to the General Conditions of the Contract and other Division 26 sections regarding Transportation and Handling and Storage and Protection.
- B. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, and handling.
- C. Store equipment and materials at the site unless off-site storage is authorized in writing by the Owner. Protect stored equipment and materials from damage and weather.
- D. Coordinate deliveries of electrical materials and equipment to minimize construction site congestion. Limit each shipment of materials and equipment to the items and quantities needed for the smooth and efficient flow of installations.

**1.21 RECORD DOCUMENTS:**

- A. Refer to the General Conditions of the Contract on Project Closeout or Project Record Documents for requirements. The following paragraphs supplement the requirements of the General Conditions.
- B. Mark Drawings to indicate revisions to conduit size and location both exterior and interior; actual equipment locations, dimensioned from column lines; concealed equipment, dimensioned to column lines; distribution and branch electrical circuitry; fuse and circuit breaker size and arrangements; support and hanger details; Change Orders; concealed control system devices, and any other relevant deviations from the Contract Documents.
- C. Mark shop drawings to indicate approved substitutions; Change Orders; actual equipment and materials used.
- D. Mark luminaire schedule on drawings to indicate manufacturer and complete catalog numbers of installed equipment.
- E. Mark schedules including panelboard, switchboard, motor control center, mechanical, kitchen and similar equipment schedules on drawings to indicate installed equipment and materials used, and any deviations or revisions to electrical load data and calculations.
- F. During construction, the contractor shall maintain at the job site a set of updated construction documents for the singular purpose of recording the above information. All record drawings shall be completed in erasable pencil. These changes shall be updated weekly.

G. Revisions to the Contract Documents shall be legible and shall be prepared using the following color scheme.

1. Red shall indicate new items, deviations and routing.
2. Green shall indicate items removed or deleted.
3. Blue shall be used for relevant notes and descriptions.

H. At the completion of the project, submit these documents to the Architect/Engineer. This contract will not be considered completed until these record documents have been received and reviewed by the Architect/Engineer.

#### 1.22 OPERATION AND MAINTENANCE DATA:

- A. Refer to the General Conditions of the Contract and other Division 26 sections on project closeout or operation and maintenance data for procedures and requirements for preparation and submittal of maintenance manuals.
- B. In addition to the information required by the General Conditions of the Contract for Maintenance Data, include the following information:
  1. Description of function, normal operating characteristics and limitations, fuse curves, engineering data and tests, and complete nomenclature and commercial numbers of all replaceable parts.
  2. Manufacturer's printed operating procedures to include start-up, break-in, routine and normal operating instructions; regulation, control, stopping, shut-down, and emergency instructions; and summer and winter operating instructions.
  3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, reassembly; aligning and adjusting instructions.
  4. Servicing instructions, lubrication charts, and schedules.
  5. Complete list of parts and wiring diagrams.
  6. Names, addresses and telephone numbers of the Contractor, Sub-contractors and local company responsible for maintenance of each system or piece of equipment.
  7. All information shall be permanently bound in a 3-ring binder. The job name and address and contractor's name and address shall be placed on the cover and spine of each binder in a permanent manner. Dymo-tape is not acceptable.
  8. Copies of all test reports shall be included in the manuals.

9. Provide manuals with dividers for major sections and special equipment. Mark neatly in ink the individual equipment when more than one model or make is listed on a page. Provide detailed table of contents.

C. This contract will not be considered completed nor will final payment be made until all specified material, including test reports, is provided and the manual is reviewed by the Architect/Engineer.

#### 1.23 PRE-ORDERED EQUIPMENT:

A. To expedite delivery, the Owner may pre-order certain items of equipment as indicated on the drawings and specified in this Division. Contractor shall include in his bid, in addition to the amounts given for the pre-ordered equipment, his costs for state and local taxes (if not included in the purchase order), rigging, installation of equipment and all accessories, and any other items required which are not furnished with equipment. The successful bidder shall accept Owner's purchase orders as written.

B. The purchase orders, equipment submittals, and all responsibility for the above equipment will be turned over to the successful bidder after award of the contract. It shall be the responsibility of the successful bidder, after award of the contract, to provide the following.

1. Provide breakdown of re-stocking charges of new equipment after the following, should it occur:

- a. Release of order
- b. Shop drawings review
- c. Factory purchase of rough material
- d. Equipment on production line
- e. Equipment off production line

2. Credit information to suppliers of pre-ordered equipment, if required.

3. Purchase orders written under his company name, to the suppliers to replace Owner's purchase orders, if required.

4. Submittal data for all pre-ordered equipment.

5. Operating and maintenance information for all pre-ordered equipment. Include in Operating and Maintenance Manual for entire project.

6. Provide one (1) year guarantee on all pre-ordered equipment. Warranty shall begin at date of acceptance.
7. Accessory items and other parts not pre-purchased but required for the installation of the pre-purchased equipment.
8. Repair or replacement of equipment or parts damaged in shipping or at the jobsite.
9. Handling, moving, and storage of pre-purchased items.

C. Pre-ordered equipment consists of: TBD

#### 1.24 TESTING:

- A. Submit test reports as outlined in the General Conditions of the Contract and other Division 26 sections regarding Quality Control.
- B. Testing as required by these specifications shall pertain to all equipment, wiring, devices, etc., installed under this contract and being reused.
- C. General Scope:
  1. Perform all tests and operational checks to assure that all electrical equipment, both Contractor and Owner-supplied, is operational within industry and manufacturer's tolerances and is installed in accordance with design specifications.
  2. The tests and operational checks shall determine the suitability to energize.
  3. Schedule tests and give a minimum of two (2) weeks advance notice to the Architect. Reschedule testing for Owner convenience if required.
- D. Test Report: Submit three copies of the completed report to the Architect no later than fifteen (15) days after completion of test unless directed otherwise. The test report shall be bound and its contents certified.

The test report shall include the following:

1. Project information including: Building, name, address, date, and other pertinent information.
2. List of equipment tested.
3. Description of test.
4. List of test equipment used and calibration date.

5. Baseline, accepted, or published target value for test with code or standard reference indicating where value was derived.
6. Test results that summarize all measured values with baseline values.
7. Conclusions and recommendations.
8. Appendix, including appropriate test forms that show all measured values.

**E. Failure to Meet Test:**

1. Any system material or workmanship which is found defective on the basis of performance tests shall be reported directly to the Architect.
2. All failed tests shall be sent immediately by fax/email to Engineer with proposed corrective action and proposed re-test date and time.
3. Contractor shall replace the defective material or equipment as necessary and repeat test until test results prove satisfactory without additional cost to the Owner.
4. The Contractor or testing agency shall have a calibration program which maintains all applicable test instrumentation within rated accuracy. The accuracy shall be traceable to the National Institute of Standards and Technology (NIST) in an unbroken chain. Instruments shall be calibrated in accordance with the following frequency schedule:
  - a. Field Instruments: 6 months
  - b. Laboratory Instruments: 12 months
  - c. Leased specialty equipment: 12 months (where accuracy is guaranteed by lessor, i.e., Doble).

Dated calibration labels shall be visible on all test equipment.

**F. Independent Testing Agency:**

1. The tests and/or operational checks indicated hereinafter in these Specifications shall be performed by a recognized independent testing agency engaged and paid for by the Contractor.
2. The testing agency shall meet federal OSHA criteria for accreditation of testing laboratories, Title 29, Part 1907. Membership in the National Electric Testing Association constitutes proof of meeting such criteria.



3. The testing agency shall be responsible for implementing all final settings and adjustments on protective devices in accordance with Owner's specified values.
4. Testing Agencies: Subject to compliance with requirements and qualifications, the following are accepted agencies:
  - a. Electro-Test, Inc.
  - b. Electrical Reliability Services

G. Independent Testing Agency requirements shall apply to the following Division 26 sections:

1. 26 24 13 - Switchboards
2. 26 24 16 - Panelboards
3. 26 05 26 - Ground Fault Protection Systems
4. 26 28 00 - Overcurrent Protective Devices
5. 23 05 13 - Motors, Starters and Drives
6. 26 29 23 - Motor Variable Frequency Drive
7. 26 36 23 - Transfer Switches

All work described in each section under field quality control shall be accomplished by the Independent Testing Agency.

**1.25 DEMOLITION/REMODEL WORK:**

- A. Refer to the General Conditions of the Contract and other Division 26 sections on Summary of Work for requirements on working in Owner-occupied areas of the existing building and to Division 2 and 26 sections on Selective Demolition. See also the following additions and modifications.
- B. The project involves renovation and remodel of the existing building. On the drawings, work may be denoted by showing items as bold or light line weight and certain renovation symbols are used. These indications and symbols are amplified as follows:
  1. Bold Print (when used): Work included in this contract is denoted in bold print or line weight.

2. Light Print (when used): Work shown lightly indicates existing conditions to remain.

R = Existing items to be removed. Contractor shall remove the existing item and the associated existing wiring. Where the raceway serving the equipment is accessible (via removal of suspended ceiling, crawl space, etc.) the raceway shall also be removed. Where the removal of a raceway leaves visible evidence on an existing surface which is not being repaired or replaced by the General Contractor, this contractor shall repair the surface. Where the existing raceway is concealed, the outlet box shall be cleaned, and a blank coverplate installed. Where the concealed raceway is uncovered by demolition performed by the General Contractor, the raceway shall be removed (or extended to new location if appropriate).

E = Existing item to remain in place. Contractor shall perform the following function based upon the item to remain:

Luminaires - Leave in place.

Switches - Maintain circuit continuity.

Receptacle - Remove devices if required for new work and reinstall.

Clock - Clean and reinstall.

ER = Existing item to remain in place; replace device. Contractor shall perform the following function based upon the item to remain:

Luminaires - Clean and install new lamps.

Switches - Remove and replace with new in existing box.

Receptacles - Remove and replace with new in existing box.

Clock - Clean and replace.

RL = Existing item to be relocated. Contractor shall remove the existing item, and store in a safe place. The existing item shall be relocated to the new position as called for on the drawings. At Contractor's option, the existing wiring may be extended, or new wiring may be run from the source. Based upon the item to be relocated, the Contractor shall perform the following function:

Luminaires - Clean and install new lamps.

- Switches - Replace.
- Receptacles - Replace.
- Clocks - Clean and relocate.

- C. Existing equipment that is removed and not scheduled to be reused shall remain the property of the Owner and be delivered for disposition unless specifically indicated otherwise and shall be stored in a location designated by the Owner. Items which are removed and not wanted by the Owner shall become the property of the Contractor and shall be removed from the site.
- D. Existing equipment that is removed and is to be reused shall be cleaned, serviced and operable before being reinstalled.
- E. Revise panelboard schedules to reflect removal or relocation of equipment. Circuit integrity of equipment in adjacent areas shall be left intact.
- F. Where remodeling interferes with existing circuits and equipment which are not to be removed, such circuits and equipment shall be reworked and relocated as required to complete the project.
- G. The Contractor shall remove all distribution equipment, conductors, etc., which are indicated to be removed or which must be removed to accommodate demolition. Equipment to be removed may require reworking conduit and wiring in order to maintain service to other equipment.
- H. Where remodeling interferes with circuits serving areas outside of the project or phase limits or which are remodeled in later phases of the project, circuits shall be reworked or temporary circuits provided as required.
- I. Existing equipment and circuiting shown are based on field surveys and/or Owner furnished drawings. The Contractor shall verify conditions as they exist with necessary adjustments being made to the drawing information.
- J. Coordinate the routing of all conduits with the existing mechanical and plumbing systems in order to avoid conflicts with ducts, pipes, etc. Where existing electrical boxes, conduit, or equipment interfere with installation of new ducts, plumbing, walls, soffits, luminaires, outlets, etc., the Contractor shall resolve the conflict with the appropriate trade.
- K. Reuse of existing luminaires, devices, conduits, boxes, or equipment will be permitted only where specifically indicated on the drawings or allowed under the appropriate section of the specifications.

- L. Electrical Outages: Electrical outages must be held to a minimum. The Contractor shall submit a Method of Procedure (MOP) for each outage to the Owner detailing the reasons for the outage, areas affected, sequence of procedures to accomplish work, estimated maximum length of time, the date and time of day outage will occur. The Contractor shall meet with the Owner to set a schedule and date for the outage based on the MOP. Due to the critical implications of power outages, the Owner may direct the Contractor as to the time of day or night and date an outage may take place.
  - 1. The Contractor will be responsible for providing temporary power required for the duration of the outages. The required outages to connect and disconnect the temporary power will require a MOP as described above.
- M. If other suspected hazardous material, in any form, is discovered by this Contractor in the process of his work, he shall report such occurrence to the Architect immediately. The Engineer will determine the action to be taken. Hazardous material removal is not a part of the work to be done under this Division.
- N. When called for in the specifications, or on the drawings, the Contractor shall meter the points indicated for thirty (30) consecutive days using a three-phase analyzer. The analyzer shall be set up to record amperes for each phase at 15 minute intervals. The Contractor shall compile a summary report, listing maximum readings and submit the report and tape to the Electrical Engineer. The analyzer shall have been calibrated within the previous 60 days. Submit documentation of the calibration to the Engineer.
- O. Contractor is responsible for sending removed lamps to be recycled. The Contractor should ensure the recycling agency meets RCRA and CERCLA regulations. Provide certificate of compliance in O&M Manuals.

#### 1.26 WARRANTIES:

- A. Refer to the General Conditions of the Contract on Warranties and Bonds and to other Division 26 sections for procedures and submittal requirements for warranties. Refer to individual equipment specifications for warranty requirements. In no case shall the warranty for the total electrical system be less than one year from date of acceptance by the Owner.
- B. Compile and assemble the warranties specified in Division 26 into a separated set of vinyl covered, three-ring binders, tabulated and indexed for easy reference.
- C. Provide complete warranty information for each item. Information to include product or equipment description, date of beginning of warranty or bond; duration of warranty or bond; and names, addresses, and telephone numbers and procedures for filing a claim and obtaining warranty services.

**1.27 CLEANING:**

- A. Refer to the General Conditions of the Contract on project closeout or final cleaning for general requirements for final cleaning.
- B. Clean all luminaires, lamps and lenses per manufacturer's recommendation prior to final acceptance. Replace all inoperative lamps.

**1.28 CONSTRUCTION REQUIREMENTS:**

- A. The Contractor shall maintain and have available at the jobsite current information on the following at all times:
  - 1. Up-to-date record drawings.
  - 2. Equipment/Device/Product Submittals
  - 3. Site observation reports with current status of all action items.
  - 4. Test results; including recorded values, procedures, and other findings.
  - 5. Outage information.

Division 26

SPEC SECTION	ITEM	REQUIREMENTS									
		REPORT/ DATA		TEST	FACTORY TEST	REPORT	FACTORY REP	SUPERVISION AT SITE	TRAINING REQD AT SITE	EXTRA MATERIAL	O & M
		SHOP DRAWING	LISTING PRODUCT								
26 05 00	SCHEDULE OF VALUES					X				X	
	ELECTRICAL COORDINATION DRAWINGS	X									
	CONTRACTOR/EQUIPMENT WARRANTIES									X	
	O&M MANUALS	X	X						X	X	
26 05 33.13	RACEWAYS		X								
	ELECTRICAL METALLIC TUBING		X								
	FLEXIBLE METAL CONDUIT		X								
	INTERMEDIATE METAL CONDUIT		X								
	LIQUID-TIGHT FLEXIBLE CONDUIT		X								
	NON-METALLIC CONDUIT PVC		X								
	RIGID METAL CONDUIT		X								
	SURFACE METAL RACEWAY	X	X							X	
	WIREWAYS	X	X							X	
	RIGID ALUMINUM CONDUIT		X								
26 05 36	CABLE TRAY	X	X							X	
	LADDER	X	X							X	

SPEC SECTION	ITEM	REQUIREMENTS									
		REPORT/ DATA		TEST	FACTORY TEST	REPORT	FACTORY REP	SUPERVISION AT SITE	TRAINING REQD AT SITE	EXTRA MATERIAL	O & M
		SHOP DRAWING	LISTING PRODUCT								
	TROUGH	X	X							X	
	SOLID BOTTOM	X	X							X	
	CHANNEL	X	X							X	
26 05 19	WIRES & CABLES		X	X		X				X	
26 05 33.16	CABINETS, BOXES & FITTINGS	X	X							X	
26 05 83	ELECTRICAL CONNECTIONS FOR EQUIPMENT		X	X							
26 27 26	WIRING DEVICES		X	X						X	
26 05 29	SUPPORTING DEVICES	X	X							X	
26 05 53	ELECTRICAL IDENTIFICATION	X	X								
26 24 13	SWITCHBOARDS	X	X	X	X	X	X	X	X	X	
26 05 26	GROUNDING	X	X	X		X				X	
26 22 00	TRANSFORMERS	X	X	X		X				X	
26 25 00	BUSWAYS	X	X	X		X				X	
26 24 16	PANELBOARDS	X	X	X		X			X	X	
26 26 00	COMPUTER ROOM - POWER DISTRIBUTION EQUIPMENT	X	X	X		X	X	X		X	
26 28 00	OVERCURRENT PROTECTIVE DEVICES	X	X	X		X		X	X	X	
23 05 13	MOTOR CONTROL CENTERS	X	X	X		X	X	X	X	X	
26 29 23	MOTOR VARIABLE FREQUENCY DRIVE	X	X	X	X	X	(2)X	X		X	

SPEC SECTION	ITEM	REQUIREMENTS									
		REPORT/ DATA		TEST	FACTORY TEST	REPORT	FACTORY REP	SUPERVISION AT SITE	TRAINING REQD AT SITE	EXTRA MATERIAL	O & M
		SHOP DRAWING	LISTING PRODUCT								
26 36 23	TRANSFER SWITCHES	X	X	X	X	X	X	X		X	
26 56 13	POLES & STANDARDS		X							X	
26 50 00	LIGHTING	X	X	X					X	X	
26 50 00	BALLASTS	X	X	X						X	
26 52 00	EMERGENCY LIGHTING	X	X	X						X	
26 32 13	PACKAGED GENERATOR SETS	X	X	X	X	X	X	X	X	X	
26 05 26	GROUND-FAULT PROTECTION	X	X	X		X				X	
26 43 13	TRANSIENT VOLTAGE SURGE SUPPRESSOR	X	X	X	X	X				X	
28 31 00	FIRE ALARM SYSTEMS	X	X	X		X	X	X		X	
27 30 00	CLOCK & PROGRAM SYSTEMS	X	X	X						X	
26 30 00	PUBLIC ADDRESS, INTERCOM & MUSIC SYSTEMS	X	X	X		X	X	X		X	
26 51 13	LIGHTING CONTROL EQUIPMENT	X	X	X				X	X	X	



**ELECTRICAL PRODUCT LISTING**

Page \_\_\_\_\_ of \_\_\_\_\_

Project Name \_\_\_\_\_

Date \_\_\_\_\_

Contractor \_\_\_\_\_

The following is a listing of equipment and materials which will be used on the above-referenced project. This product listing does not remove the requirement for submittal of Shop Drawings, Product Data or Samples as may be called for elsewhere in these specifications. Provide this list to Architect/Engineer within 4 weeks of contract award.

SPEC SECTION	ITEM	MANUFACTURE R PROPOSED	LEAD TIME (WKS)


**END OF SECTION 26 05 00**

**SECTION 26 05 19 - WIRES AND CABLES**

**PART 1 - GENERAL**

**1.1 SUMMARY:**

- A. This section includes wires, cables, and connectors for power, lighting, signal, control, and related systems rated 600 volts and less.

**1.2 QUALITY ASSURANCE:**

- A. Manufacturers: Firms regularly engaged in manufacture of electrical wire and cable products of types, sizes, and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years.

- B. Installer's Qualifications: Firm with at least 3 years of successful installation experience with projects utilizing electrical wiring and cabling work similar to that required for this project.
- C. Conform to applicable code regulations regarding toxicity of combustion products of insulating materials.

### 1.3 SUBMITTALS:

- A. Product Data: Submit manufacturer's data on electrical wires, cables and connectors.

### 1.4 DELIVERY, STORAGE, AND HANDLING:

- A. Deliver wire and cable properly packaged in factory- fabricated type containers, or wound on NEMA-specified type wire and cable reels.
- B. Store wire and cable in clean dry space in original containers. Protect products from weather, damaging fumes, construction debris and traffic.
- C. Handle wire and cable carefully to avoid abrading, puncturing and tearing wire and cable insulation and sheathing. Ensure that dielectric resistance integrity of wires/cables is maintained.

## PART 2 - PRODUCTS

### 2.1 ACCEPTABLE MANUFACTURERS:

- A. Manufacturers: Subject to compliance with requirements, provide products by the following (for each type of wire, cable, and connector):

#### 1. Wire and Cable:

American Insulated Wire

Anaconda-Ericsson Inc, Wire and Cable Div.

Belden Div, Cooper Industries.

Brand-Rex Div, Pyle National Co.

General Cable Corporation.

Hitemp Wires, Inc.

Phelps Dodge Cable and Wire Co.

Rome Cable Corp.

Southwire Company

Okonite

Superior Essex:

- 1) Triangle
- 2) Excel
- 3) Royal

2. Connectors:

- a. O-Z/Gedney Co.
- b. AMP, Inc.
- c. Burndy Corporation.
- d. Ideal Industries, Inc.
- e. 3M Company
- f. Thomas and Betts Corp.

2.2 WIRES AND CABLES:

- A. General: Provide wire and cable suitable for the temperature, conditions, and location where installed. Building wire shall be insulated with THHN/THWN/XHHW insulation, rated 600 volt.
- B. Conductors: Provide solid conductors for power, control, and lighting circuits 10 AWG and smaller. Provide stranded conductors for 8 AWG and larger.
- C. Conductor Material: Provide copper for all wires and cables.
  1. Metal Clad Cable - Type MC: Sizes 14 AWG through 10 AWG, copper conductors with 600 volt thermoplastic insulation rated 90 degrees C, steel OR aluminum interlocked metal type covering.
  2. Armored-Type HCF Cable: Sizes 14 AWG through 10 AWG, copper conductors with 600 volt thermoplastic insulation rated 90degrees C, steel OR aluminum interlocked metal type armor and bond wire that is clearly identified as an acceptable return grounding path. A green insulated equipment grounding conductor shall be included in the assembly. Armor shall be galvanized steel, color coated green.

3. Portable Cord:
  - a. Type SO: Sizes 14 AWG through 2 AWG, copper conductors with 600 volt thermoset insulation o.1 resistant insulation.
  - b. Type G-GC: Sizes 1 AWG through 500 KCMIL, copper conductors with 600/2000 volt, 90 degrees C, ethylene-propylene insulation.
4. Cables: Provide the following types of cables in NEC approved locations and applications where permitted by the contract documents. Cables shall be U.L. listed and approved by the local building authority. All cables shall contain a green insulated equipment ground conductor of the same size as the neutral conductor.

### 2.3 CONNECTORS:

- A. General: Provide UL-type factory-fabricated, solderless metal connectors of sizes, ampacity ratings, materials, types and classes for applications and for services indicated. Use connectors with temperatures equal to or greater than those of the wires upon which used.
- B. Splitbolt, setscrew, compression, wingnut, wirenut and Scotchlock connectors are acceptable. Push, quick- and stab-lock or similar connectors are prohibited at LPS.
- C. Provide 2-hole compression lugs for all power feeder, neutral, and grounding connections (including phase, neutral and grounding conductors).
- D. Provide connectors that are designed to accept stranded conductors where stranded conductors are used.

## PART 3 - EXECUTION

### 3.1 WIRE AND CABLE INSTALLATION SCHEDULE:

- A. Building Wire: Install all building wire in raceway regardless of location.
- B. Metal Clad Cable/HCF:
  1. Maximum of 6 feet length for connecting luminaires in accessible ceilings to the local junction box.
  2. Maximum of 3 feet length for connecting luminaires in non-accessible ceilings to the local junction box.
  3. In stud walls and casework for horizontal branch circuit runs between devices.
  4. For vertical branch circuit drops from a local junction box above an accessible ceiling to the direct or single device in a stud wall, casework, under-cabinet lighting.

5. May not be used for branch circuit home runs, feeders, motor feeder circuits or in the following locations:

Hazardous locations

Emergency Systems

- C. Portable Cord: Use for flexible pendant leads to luminaires, outlets, and equipment where indicated and in compliance with codes.

### 3.2 INSTALLATION OF WIRES AND CABLES:

- A. General: Install electrical cables, wires and connectors in compliance with applicable requirements of NEC, NEMA, UL, and NECA's "Standard of Installation", and in accordance with recognized industry practices.
- B. Coordinate wire/cable installation work, including electrical raceway and equipment connection work, with other work.
- C. Pull conductors simultaneously where more than one is being installed in same raceway. Use pulling compound or lubricant, where necessary; compound used must not deteriorate conductor or insulation.
- D. Use pulling means including, fish tape, cable, rope and basket weave wire/cable grips which will not damage cables or raceway. Do not use rope hitches for pulling attachment to wire or cable.
- E. Keep conductor splices to minimum. Splice only in accessible junction boxes. No splices are allowed in feeder, control or fire alarm wiring. Connect unspliced wire to numbered terminal strips at each end.
- F. Install splices and taps which possess equivalent or better mechanical strength and insulation ratings than conductors being spliced.
- G. Use splice and tap connectors which are compatible with conductor material.
- H. Tighten electrical connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque values. Where manufacturer's torque requirements are not indicated, tighten connectors and terminals to comply with torque values specified in UL Std 486A for copper and 486B for aluminum.
- I. Support cables above accessible ceilings, do not rest cables on ceiling tiles. Use spring clips and hanger rods independent from the ceiling suspension system to support cables from structure.

- J. Provide adequate length of conductors within electrical enclosures and train the conductors to terminal points with no excess. Bundle multiple conductors, with conductors larger than No. 10 AWG cabled to individual circuits. Make terminations so there is no bare conductor at the terminal.
- K. Use solderless pressure connectors with insulating covers for copper wire splices and taps, 8 AWG and larger. For 10 AWG and smaller, use insulated screw-on type spring wire connectors with plastic caps; push-on or stab-in type wire nuts are not acceptable.
- L. Use copper compression connectors for copper wire splices and taps, 1/0 AWG and larger. Tape uninsulated conductors and connectors with electrical tape to 150 percent of the insulation value of the conductor.
- M. Make splices, taps and terminations to carry full ampacity of conductors without perceptible temperature rise.
- N. Thoroughly tape the ends of spare conductors in boxes and cabinets.
- O. Install exposed cable, parallel and perpendicular to surfaces, or exposed structural members, and follow surface contours, where possible.
- P. Make all ground, neutral and line connections to receptacle and wiring device terminals as recommended by manufacturer. Provide ground jumper from outlet box to individual ground terminal of devices.
- Q. Branch circuits whose length from panel to first outlet exceeds 100 feet for 120 volt circuits or 175 feet for 277 volt circuit shall be #10 or larger, as required to comply with the National Electrical Code.
- R. Parallel conductors shall be cut to the same length.
- S. All splices in control panels, terminal junction boxes, low voltage control circuits and fire alarm conductors shall be on numbered terminal strip.
- T. Where conduit is not required, plenum rated cable shall be provided in ceiling, floor or other air plenum spaces.
- U. Provide wire training, lacing, labeling, and terminal blocks as required in panelboards and all control cabinets including, but not limited to, lighting, transfer switch, and fire alarm cabinets. All wiring shall be installed neat and be labeled to match wiring diagrams, control devices, etc.
  - 1. Make temporary connections to panelboard devices with sufficient slack conductor to facilitate reconnections required for balancing loads between phases.

- V. Color coding of switchlegs, travelers, etc. shall be different and distinct from phase and neutral conductors. Where systems utilize two (2) different voltages, the color coding of switchlegs, travelers, etc. shall be different and distinct for each voltage system.

**3.3 FIELD QUALITY CONTROL:**

- A. Prior to energizing of circuitry, check installed wires and cables with 1000 VDC megohm meter to determine insulation resistance levels to ensure requirements are fulfilled. Test shall be made on all feeders regardless of size and on all branch circuits with No. 4 AWG and larger conductors. The megger values obtained shall be compared to the minimum values listed in NETA. All phase conductors and cables shall be meggered after installation, and prior to termination. Submit test report.
  
- B. Prior to energizing, test wires and cables for electrical continuity and for short-circuit faults.
  
- C. Subsequent to wire and cable hook-ups, energize circuitry and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance.

**3.4 COLOR CODING SCHEDULE:**

- A. Color code secondary service, feeder, and branch circuit conductors as follows:

<u>120/208 Volts</u>	<u>Phase</u>	<u>277/480 Volts</u>
Black	A	Brown
Red	B	Orange
Blue	C	Yellow
White	Neutral	Gray
Green	Ground	Green

- B. Conductors shall be solid color for entire length.
  
- C. If solid color conductors are not available and specific acceptance is given by the engineer for use of black conductor insulation, provide the following:
  - 1. Conductors 10 AWG and smaller shall be solid color for the entire length.
  
  - 2. Conductors 8 AWG and larger shall be black with color coding at each termination and in each box or enclosure. For a distance of 6 inches use half-lapped 3/4 inch plastic tape



in the specified color. Do not cover cable identification markings. Adjust tape locations to prevent covering of markings.

**END OF SECTION 26 05 19**

**SECTION 26 05 26 – GROUND-FAULT PROTECTION SYSTEMS****PART 1 - GENERAL****1.1 SUMMARY:**

- A. Extent of ground-fault protection work is indicated by drawings and schedules, and by requirements of this section.
- B. Applications of ground-fault protection units required for project include the following:
  - 1. Single service disconnect.
  - 2. Feeder and branch circuits.

**1.2 SUBMITTALS:**

- A. Product Data: Submit manufacturer's data on ground-fault protection devices and associated components including, but not limited to, types, sizes, basic ampere ratings, and control voltages.
- B. Shop Drawings: Submit layout drawings of installed ground-fault protection devices and accessories including sensors, current monitors, and test panels.
- C. Wiring Diagrams: Submit ground-fault protection systems wiring diagrams showing, but not limited to, splices, connectors, and interconnections to equipment. Include routing and spatial relationships to adjacent electrical power and signal wiring.

**1.3 QUALITY ASSURANCE:**

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of ground-fault protection units of types, ratings and characteristics required, whose products have been in satisfactory use in similar service for not less than 3 years.
- B. Installer's Qualifications: Firm with at least 3 years of successful installation experience with projects utilizing ground-fault protection work similar to that required for this project.
- C. Codes and Standards:
  - 1. UL Compliance: Comply with applicable requirements of Std 486A, "Wire Connectors and Soldering Lugs for Use with Copper Conductors", and Std 1053, "Ground-Fault Sensing and Relaying Equipment." Provide ground-fault protection systems and components which are UL-listed and labeled.
  - 2. IEEE Compliance: Comply with applicable recommended practice of IEEE Standards 142, 241 and 242 pertaining to ground-fault protection devices.

**1.4 DELIVERY, STORAGE AND HANDLING:**

- A. Deliver ground-fault protection units properly packaged in factory-fabricated containers.
- B. Store ground-fault protection units indoors, in clean, dry space. Retain units, until installed, in original cartons and protect from dirt, weather, construction debris and traffic.
- C. Handle ground-fault protection units properly to avoid abrading, cracking, and breaking.

**PART 2 - PRODUCTS****2.1 MANUFACTURERS:**

- A. Manufacturers: Subject to compliance with requirements, provide ground-fault protection units of one of the following (for each type of unit):
  - 1. General Electric Co.
  - 2. Siemens
  - 3. Square D Co.
  - 4. Westinghouse Electric Corp.
  - 5. Allen-Bradley Co.
  - 6. ASEA/Brown Boveri Electric Inc.
  - 7. Gould Inc.

**2.2 GROUND FAULT PROTECTION SYSTEMS AND DEVICES:**

- A. General: Except as otherwise indicated, provide ground-fault protection systems, including devices and components, of types, sizes, characteristics, and ratings indicated, which comply with manufacturer's standard materials, design and construction in accordance with published product information, and as required for complete installation. Where types, sizes, or ratings are not indicated, comply with NEC, UL and established industry standards for applications indicated.
- B. Circuit Interrupters/Circuit Breakers: Provide 1 inch wide module bolt-on panelboard circuit breakers, with integral ground-fault circuit interrupters, UL-rated Class A, Group 1; 20-amperes ratings, 2-pole construction, 120/240-volts, 60 Hz, 10,000 AIC. Provide units with solid-state ground-fault sensing and signaling, with 5 milliamperes ground-fault

sensitivity trip level, with accuracy of plus or minus 1 milliampere. Equip with PUSH-TO-TEST capability. Provide modules which mate and match panelboards in which they are located.

C. Ground-Fault Protection Systems:

1. General: Provide ground-fault protection systems for grounded electrical systems, 600-volts, 60Hz, comprised of current monitor, shunt trip relaying equipment, including solid-state relays, and static ground-fault current sensors of sufficient size to encircle phase conductors and neutral conductor of circuit to be monitored. Select GFP systems with monitor panels, and low-voltage power circuit-breakers; select units which function properly in conjunction with other elements of GFP system. Provide ground-fault current sensitivity and time-current response characteristics as indicated. Construct system components and devices with the following features:
2. Current Sensors: Provide zero-sequence current sensors with rectangular windows for feeder and branch devices and ground return sensors for main service device; inputs compatible to relay. Construct sensor of split-core construction which can be opened to expedite its installation or removal without disturbing the electrical conductors being encompassed. Provide test windings in sensor for testing the operation of ground-fault protection unit including sensor pick-up, relay and circuit protection devices.
3. Ground-Fault Relay: Provide solid-state ground-fault signaling relay with silicon controlled rectifier (SCR) output, to be used with electric or shunt trip, which requires no external source of electrical power, drawing its energy to operate ground-fault protection system directly from output of current sensor. Select relays capable of sensing ground currents which causes the interrupter to open after current reaches a magnitude value for time period indicated. Provide relay with adjustable pick-up current sensitivity range from 10 mA to 200 mA for ground-fault currents from 100 to 1200 amperes, with calibrated dial to show pick-up point settings. Provide factory-set time delay which is adjustable from instantaneous to 15-seconds and which also prevents tampering with setting after installation.
4. Circuit Breakers: Provide molded-case circuit breakers of sizes and ratings indicated. Construct with thermal and magnetic elements for conventional overload and fault-current protection; and with ground-fault trip mechanism capable of being activated by ground-fault relay which causes opening of circuit when ground-fault occurs of the magnitude indicated.

5. Monitor Panels: Provide monitor panels with ground-fault indicators, control power indicators and TEST and RESET buttons, and with control circuitry capable of providing means for testing system with, or without interruption of service. Construct ground-fault system which cannot be left in an INACTIVE, or OFF state.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION:**

- A. Examine areas and conditions under which ground-fault protection systems and devices are to be installed, and notify Contractor in writing of conditions detrimental to proper completion of work. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

### **3.2 INSTALLATION OF GROUND-FAULT PROTECTION DEVICES:**

- A. Install ground-fault protection devices as indicated, in accordance with manufacturer's written instructions and with recognized industry practices to ensure that ground-fault protection devices comply with requirements. Comply with applicable requirements of NEC and NEMA standards for installation of ground-fault protection devices to ensure that devices fulfill requirements.
- B. Coordinate with other electrical work, including electrical wiring work, as appropriate to properly interface installation of ground-fault protection devices with other work.
- C. Install ground-fault protection devices complying with electrical winding polarities indicated.
- D. Fasten ground-fault sensing devices without mechanical stresses, twisting, or misalignment being exerted by clamps, supports, bus bars or cables.
- E. Install ground-fault sensing windows symmetrically encircling power conductor bus bars or cables. Maintain clearances between conductors and ground-fault sensor body as recommended by device manufacturer.

### **3.3 GROUNDING:**

- A. Provide grounding connections for ground-fault systems and units as indicated. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque values for equipment connectors. Where manufacturer's torque requirements are not indicated, tighten connectors and terminals to comply with torque values specified in UL Standard 486A.

### **3.4 ADJUSTING:**

- A. Set field-adjustable GFP devices for pickup and time sensitivity ranges as indicated by short circuit and overcurrent study, subsequent to installation of devices.
- B. Perform Ground fault coordination study. Set field-adjustable pick-up and time-sensitivity ranges accordingly.

**3.5 FIELD QUALITY CONTROL:**

- A. Upon completion of installation of ground-fault protection devices and after electrical circuitry has been energized, demonstrate capability, and compliance with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.

**END OF SECTION 25 06 26**

**SECTION 26 05 29 - SUPPORTING DEVICES****PART 1 - GENERAL****1.1 SUMMARY:**

- A. This Section includes secure support from the building structure for electrical items by means of hangers, supports, anchors, sleeves, inserts, seals, and associated fastenings.

**1.2 SUBMITTALS:**

- A. Product data for each type of product specified.
  - 1. Hanger and support schedule showing manufacturer's figure number, size, spacing, features, and application for each required type of hanger, support, sleeve, seal, and fastener to be used.
- B. Shop drawings indicating details of fabricated products and materials.
- C. Engineered Design consisting of details and engineering analysis for supports for the following items:
  - 1. Suspended transformers
  - 2. Cable trays
  - 3. Trapeze hangers for multiple conduit runs.

**PART 2 - PRODUCTS****2.1 MANUFACTURERS:**

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
  - 1. Slotted Metal Angle and U-Channel Systems:
    - a. Unistrut Diversified Products
    - b. Allied Tube & Conduit
    - c. B-Line Systems, Inc.
    - d. GS Metals Corp.
  - 2. Conduit Sealing Bushings:
    - a. O-Z/Gedney

- b. Cooper Industries, Inc.
- c. Madison Equipment Co.
- d. Raco, Inc.
- e. Spring City Electrical Mfg. Co.
- f. Thomas & Betts Corp.

**2.2 COATINGS:**

- A. Coating: Supports, support hardware, and fasteners shall be protected with zinc coating or with treatment of equivalent corrosion resistance using approved alternative treatment, finish, or inherent material characteristic. Products for use outdoors shall be hot-dip galvanized.

**2.3 MANUFACTURED SUPPORTING DEVICES:**

- A. Raceway Supports: Clevis hangers, riser clamps, conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps.
- B. Fasteners: Types, materials, and construction features as follows:
  - 1. Expansion Anchors: Carbon steel wedge or sleeve type.
  - 2. Toggle Bolts: All steel springhead type.
  - 3. Powder-Driven Threaded Studs: Heat-treated steel, designed specifically for the intended service.
- C. Conduit Sealing Bushings: Factory-fabricated, watertight conduit sealing bushing assemblies suitable for sealing around conduit, or tubing passing through concrete floors and walls. Construct seals with steel sleeve, malleable iron body, neoprene sealing grommets or rings, metal pressure rings, pressure clamps, and cap screws.
- D. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for non-armored electrical cables in riser conduits. Provide plugs with number and size of conductor gripping holes as required to suit individual risers. Construct body of malleable-iron casting with hot-dip galvanized finish.
- E. U-Channel Systems: 12-gage steel channels, with 9/16 inch-diameter holes, at a minimum of 8 inches on center, in top surface. Provide fittings and accessories that mate and match with U-channel and are of the same manufacture.



F. Supports: Provide supporting devices of types, sizes and materials indicated; and having the following construction features:

1. One-Hole Conduit Straps: For supporting  $\frac{3}{4}$  inch and smaller rigid metal conduit; galvanized steel.
2. Two-Hole Conduit Straps: For supporting 1 inch and larger rigid metal conduit, galvanized steel;  $\frac{3}{4}$  inch strap width; and 2- $\frac{1}{8}$  inch between center of screw holes.

#### 2.4 FABRICATED SUPPORTING DEVICES:

- A. General: Shop or field-fabricated supports or manufactured supports assembled from U-channel components.
- B. Steel Brackets: Fabricated of angles, channels, and other standard structural shapes. Connect with welds and machine bolts to form rigid supports.
- C. Pipe Sleeves: Provide pipe sleeves of one of the following:
  1. Steel Pipe: Fabricate from Schedule 40 galvanized steel pipe.
  2. EMT, IMC, or Rigid Conduit.

#### 2.5 FIRE SEALS:

- A. Material: Firestopping material shall be asbestos free, 100 percent intumescent, have code approval under BOCA, ICBO, SSBC, NFPA 101, NFPA 70, and be capable of maintaining an effective barrier against flame and gases in compliance with the following requirements. See also requirements of Section 07 80 00.
- B. Flame Spread: 25 or less, ASTM E84
- C. Fire Resistance and Hose Stream Tests: Firestopping materials shall be rated "F" and "T" in accordance with ASTM E 814 or UL 1479. Rating periods shall conform to the following:
  - (F) 3 (T) 3 Time-rated floor or wall assemblies.
  - (F) 3 (T) 3 Openings between floor slabs and curtain wall.
- D. Manufacturers: Subject to compliance with requirements, provide fire seals of the following:
  1. 3M Company

2. Tremco

**PART 3 - EXECUTION****3.1 INSTALLATION:**

- A. Install supporting devices to fasten electrical components securely and permanently in accordance with NEC requirements.
- B. Coordinate with the building structural system and with other electrical installations.
- C. Raceway Supports: Comply with the NEC and the following requirements:
  1. Conform to manufacturer's recommendations for selection and installation of supports.
  2. Strength of each support shall be adequate to carry present and future load multiplied by a safety factor of at least four. Where this determination results in a safety allowance of less than 200 lbs, provide additional strength until there is a minimum of 200 lbs safety allowance in the strength of each support.
  3. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.
  4. Use #9 ceiling wire to support individual conduits up to 3/4inch with spring steel fasteners. Use of ceiling support wires is unacceptable.
  5. Support parallel runs of horizontal raceways together on trapeze-type hangers. Use 3/8 inch diameter or larger threaded steel rods for support.
  6. Support individual horizontal raceways by separate pipe hangers. Spring steel fasteners may be used in lieu of hangers only for 1-1/2 inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings only. For hanger rods with spring steel fasteners, use 1/4 inch-diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits or tubing. For hanger rods supporting 1-1/2 inch or larger conduits provide 3/8 inch minimum threaded steel rods with pipe hangers.
  7. Space supports for raceways in accordance with NEC. When there are four (4) or more 2-inch conduits in a trapeze, supports shall be spaced 5 feet O.C.
  8. In all runs, arrange support so the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports with no weight load on raceway terminals.

9. Threaded rod supports to have bottoms cut off at a maximum length equal to rod diameter below bottom nut.
- D. Conductor Supports: Comply with the NEC and the following requirements:
1. Support individual conductors or cables by separate clamps with rubber or plastic grommet, fasten using a non-metallic bolt and nut, and secure clamps to Unistrut supports anchored to structure (multiple clamps may be secured to a single Unistrut support). Individual conductors or cables may be served utilizing a vinyl or fiberglass clamp which shall be anchored to the structure.
  2. Space supports as follows:
    - a. Horizontal conductors not more than 3 feet o.c.
    - b. Vertical conductors not more than 5 feet o.c.
  3. Install simultaneously with installation of conductors.
- E. Miscellaneous Supports: Support miscellaneous electrical components separately and as required to produce the same structural safety factors as specified for raceway supports. Install metal channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices.
- F. In open overhead spaces, support metal boxes directly from the building structure via 1/4" minimum all-thread or by bar hangers. Where bar hangers are used, attach the bar to raceways on opposite sides of the box and support the raceway with an approved type of fastener not more than 24 inches from the box. Supporting metal boxes utilizing ceiling wire is not acceptable.
- G. Sleeves: Install in concrete slabs and walls and all other fire-rated floors and walls for cable installations as required. Where sleeves through floors are installed, extend above finish floor. For sleeves through fire rated-wall or floor construction, apply UL-listed firestopping sealant in gaps between sleeves and cables in accordance with "Fire Resistant Joint Sealers" requirements of Division 7. See Architectural plans for location and extent of fire rated assemblies.
- H. Conduit Seals: Install seals for conduit penetrations of slabs on grade and exterior walls below grade and where indicated. Tighten sleeve seal screws until sealing grommets have expanded to form watertight seal.
- I. Fastening: Unless otherwise indicated, fasten electrical items and their supporting hardware securely to the building structure, including but not limited to conduits, raceways, cables, cable trays, busways, cabinets, panelboards, transformers, boxes, disconnect switches, and control components in accordance with the following:

1. Fasten by means of wood screws or screw-type nails on wood, toggle bolts on hollow masonry units, concrete inserts or expansion bolts on concrete or solid masonry, and machine screws, welded threaded studs, or spring-tension clamps on steel. Threaded studs driven by a powder charge and provided with lock washers and nuts may be used instead of expansion bolts and machine or wood screws, where authorized by the Owner and structural engineer. Do not weld conduit, pipe straps, or items other than threaded studs to steel structures. In partitions of light steel construction, use sheet metal screws.
2. Holes cut to depth of more than 1-1/2 inches in reinforced concrete beams or to depth of more than 3/4 inch in concrete shall not cut the main reinforcing bars. Fill holes that are not used.
3. Ensure that the load applied to any fastener does not exceed 25 percent of the proof test load. Use vibration and shock-resistant fasteners for attachments to concrete slabs.

J. Communication and Telephone Cable Supports: Use No. 9 ceiling wire to support individual or small bundles of cables run above accessible ceilings.

K. Refer to "Raceways" Section 26 05 33.13 for additional requirements.

### 3.2 PERSONNEL PROTECTION:

- A. Where U-channel systems, angles, brackets or other standard structural metal shapes are readily accessible and exposed to personnel, provide plastic or rubber end caps.
- B. Where threaded rod supports are readily accessible and exposed to personnel, provide plastic or rubber end caps.

### 3.3 FIRESTOPPING LOCATIONS:

#### A. Preparation:

1. Coordination: Coordinate the work with other trades. Firestopping materials at penetrations of insulated pipes and ducts can be applied after insulation is in place. If insulation is composed of combustible material, the thickness of firestopping materials must be equivalent to that of the insulation. If the insulation is composed of non-combustible material, it may be considered as part of the penetrating item.
2. Surface Preparation: Surface Preparation to be in contact with firestopping materials shall be free of dirt, grease, oil, loose material or other substances that may affect proper fitting or the required fire resistance.

- B. Installation: Install firestopping materials in accordance with the manufacturer's instructions.
- C. Cleaning: After completion of firestopping work in any area, equipment shall be reviewed and walls, ceilings and all other surfaces not to receive firestopping shall be cleaned of deposits of firestop materials.
- D. Inspection: The architect may select and the Owner will pay an independent testing laboratory to examine firestopped areas to ensure proper installation prior to concealing or enclosing the firestopped areas.

**END OF SECTION 26 05 29**

**SECTION 26 05 33.13 - RACEWAYS****PART 1 - GENERAL****1.1 SUMMARY:**

- A. Extent of raceway work is indicated by drawings and schedules. Provide complete conduit systems for all conductors unless otherwise specified.
- A. Types of raceways specified in this section include the following:
  - 1. Electrical metallic tubing (EMT).
  - 2. Flexible metal conduit.
  - 3. Intermediate metal conduit (IMC).
  - 4. Liquid-tight flexible metal conduit.
  - 5. Non-metallic Conduit and Ducts.
  - 6. Rigid metal conduit (RGC).
  - 7. Surface metal raceways.
  - 8. Wireways.
  - 9. Rigid Aluminum Conduit.

**1.2 QUALITY ASSURANCE:**

- A. Manufacturers: Firms regularly engaged in manufacture of raceway systems of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Installer's Qualifications: Firm with at least 3 years of successful installation experience on projects with electrical raceway work similar to that required for this project.

**1.3 SUBMITTALS:**

- A. Product Data: Submit manufacturer's technical product data, including specifications and installation instructions, for each type of raceway system required. Include data substantiating that materials comply with requirements.

- B. Shop Drawings: Submit dimensioned drawings of surface metal raceway systems showing layout of raceways and fittings, spatial relationships to associated equipment, and adjoining raceways, if any. Show connections to electrical power panels and feeders.

**PART 2 - PRODUCTS****2.1 MANUFACTURERS:**

- A. Subject to compliance with requirements, provide products by the following:

1. Rigid Metal Conduit:
  - a. Allied
  - b. Triangle
  - c. Western Tube & Conduit
  - d. Wheatland
  
2. Intermediate Metal Conduit (IMC):
  - a. Allied
  - b. Triangle
  - c. Western Tube & Conduit
  
3. PVC Coated:
  - a. Perma Cote
  - b. Rob Roy
  - c. OCAL
  
4. EMT Conduit:
  - a. Allied
  - b. Triangle
  - c. Western Tube & Conduit

- d. Republic
- e. LTV
  
- 5. Non-Metallic Conduit:
  - a. Carlon
  - b. MPF
  - c. Can-Tex
  - d. PW
  
- 6. Steel Fittings:
  - a. O/Z Gedney
  - b. Raco
  - c. Appleton
  - d. EPT
  - e. Midwest
  - f. Picoma
  - g. Steel City
  
- 7. Die-cast Fittings:
  - a. Regal
  - b. Bridgeport
  - c. Halex
  - d. Raco
  
- 8. Conduit Bodies:
  - a. O/Z Gedney



- b. Killark
  - c. Regal
  - d. Appleton
  - e. Crouse Hinds
9. Surface Metal Raceways:
- a. Wiremold Co.
  - b. Walker
  - c. Square D. Co.
  - d. Isoduct Energy Systems
  - e. Airey Thompson Co.
  - f. B-Line Systems, Inc.

10. Wireway:
- a. Square D. Co.
  - b. Circle AW Products
  - c. Erickson Electric Equipment Co.
  - d. G.S. Metals Corp.
  - e. Hoffman Engineering Co.
  - f. Wadsworth Electric Mfg. Co., Inc.

**2.2 METAL CONDUIT AND TUBING:**

**A. Rigid Galvanized Steel Conduit (RGC):**

- 1. Conduit: Rigid steel, zinc-coated inside and outside, threaded ends.
- 2. Fittings: Threaded galvanized steel, bushings shall have nylon insulated throat.

**B. Intermediate Metal Conduit (IMC):**

1. Conduit: Rigid intermediate grade galvanized inside and outside, threaded ends.
2. Fittings: Threaded galvanized steel, bushings shall have nylon insulated throat.

**C. PVC Externally Coated Rigid Steel Conduit:**

1. Conduit: Rigid steel zinc-coated with external coating of PVC.
2. Fittings: Threaded galvanized steel with external PVC coating, bushings shall have nylon insulated throat.

**D. Electrical Metallic Tubing (EMT):**

1. Conduit: Galvanized steel tubing.
2. Fittings: Steel compression fittings for damp and wet locations. Bushings shall be threaded and have nylon insulated throat or nylon bushing.
3. Set-screw connectors and couplings are acceptable for dry locations.
4. Die-cast compression fittings will not be permitted.

**E. Rigid Aluminum Conduit:**

1. Not allowed unless otherwise noted.

**F. Flexible Metal Conduit:**

1. Conduit: Continuous spiral wound, interlocked, zinc-coated steel, approved for grounding.
2. Fittings: Cadmium plated, malleable iron. Straight connector shall be one-piece body, female end with clamp and deep-slotted machine screw for securing conduit, and threaded male end with locknut. Angle connectors shall be two piece body with removable upper section, female end with clamp and deep-slotted machine screw for securing conduit, and threaded male end with locknut. All fittings shall be terminated with threaded bushings having nylon insulated throats.

**G. Liquid-Tight Flexible Metal Conduit:**

1. Conduit: Continuous spiral wound, interlocked zinc-coated steel with polyvinyl chloride (PVC) jacket, approved for grounding.
2. Fittings: Cadmium plated malleable iron. Straight and angle connectors shall be the same as used with flexible metal conduit but shall be provided with a compression type steel ferrule and neoprene gasket sealing rings.

### 2.3 NON-METALLIC CONDUIT AND DUCTS:

#### A. Rigid Non-Metallic Conduit (RNC):

1. Conduit: Schedule 40 or 80 polyvinyl chloride (PVC), 90°C for direct burial or concrete encasement.
2. Fittings: Mate and match conduit type and material. Cement as recommended by manufacturer.

#### B. PVC and ABS Plastic Utilities Duct:

1. Conduit: Type 2 (EB) for encased burial in concrete; Type II (DB) for direct burial.
2. Fittings: Mate and match conduit type and material. Cement as recommended by manufacturer.

### 2.4 CONDUIT BODIES:

- A. General: Types, shapes and sizes, as required to suit individual applications and NEC requirements. Provide matching, gasketed covers secured with corrosion-resistant screws.
- B. Metallic Conduit and Tubing: Use malleable iron conduit bodies. Use bodies with threaded hubs for threaded raceways and in hazardous locations.
- C. Nonmetallic Conduit: Use nonmetallic conduit bodies.

### 2.5 WIREWAYS:

- A. General: Provide electrical wireways of types, grades, sizes, and number of channels for each type of service as indicated. Provide complete assembly of raceway including, but not limited to, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other components and accessories as required for complete system.

- B. Lay-In Wireways: Construct lay-in wireways with hinged covers in accordance with UL 870 with components UL listed. Construct units to be capable of sealing cover in closed position with sealing wire. Provide wireways with knockouts.
  - 1. Connectors: Provide wireway connectors suitable for "lay-in" conductors, with connector covers permanently attached so that removal is not necessary to utilize the lay-in feature.
  - 2. Finish: Protect sheet metal parts with rust inhibiting coating and baked enamel finish. Plate-finish hardware to prevent corrosion. Protect screws installed toward inside of wireway with spring nuts to prevent wire insulation damage.
- C. Rain-tight Troughs: Construct in accordance with UL 870, with components UL listed.
  - 1. Construction: 16-gauge galvanized sheet metal parts for 4" x 4" to 6" x 6" sections, and 14-gauge parts for 8" x 8" and larger sections. Provide knockouts only in bottom of troughs, with suitable adapters to facilitate attaching to other NEMA 3R enclosures. Do not use gasket material that can rip or tear during installation, or would compromise rain-tight capability of the trough. Do not use cover screws that will protrude into the trough area and damage wire insulation.
  - 2. Finish: Provide 14-gauge and 16-gauge galvanized sheet metal parts with corrosion-resistant phosphate primer and baked enamel finish. Plate-finish hardware to prevent corrosion.

## 2.6 SURFACE METAL RACEWAYS:

- A. General: Sizes and channels as indicated. Provide fittings that match and mate with raceway. All circuits either factory or field installed shall have a separate neutral conductor.
  - 1. Type 1: Multi-outlet assembly with pre-wired outlets, 3-wire, single circuit with single outlets on 6 / 9 / 12 / 18 inch centers.
  - 2. Type 2: Multi-outlet assembly with pre-wired outlets, 2-circuit with single outlets wired alternately on 6 / 9 / 12 / 18 inch centers.
  - 3. Type 3: Single compartment, multi-outlet assembly, nominal 2-3/4" x 1-7/16" with flush, snap-on cover. Install devices and circuits as indicated on the drawings.
  - 4. Type 4: Multi-outlet assembly, divided for power and communication, nominal 4-3/4" x 1-3/4" with (2), 2-3/8" compartments and flush, snap-on cover. Install devices and circuits as indicated on the drawings.
  - 5. Type 5: Single compartment, multi-outlet assembly, nominal 4-3/4" x 3-9/16" with flush, snap-on cover. Install devices and circuits as indicated on the drawings.

6. Surface Metal Raceway: Galvanized steel with snap-on cover. Finish in manufacturer's standard prime coating suitable for field painting. Provide raceways of suitable size based on fill for circuits indicated on the drawings. Provide all necessary boxes, covers, extensions, fittings, etc. to form a complete assembly.

B. Boxes for Surface Raceways: Designed, manufactured and supplied by raceway manufacturer for use with specified raceway.

## 2.7 CONDUIT SIZES:

A. Conduit sizes shall be as shown on the drawings. If the conduit size is not given on the drawings, the conduit shall be sized in accordance with NEC based on the number of conductors enclosed plus a parity sized equipment ground conductor and be subject to the following minimum sizes:

1. Rigid, Intermediate, and EMT Conduit: 3/4 inch for all runs except lighting switch legs, 277 volt lighting branch circuits, temperature control and fire alarm which may be 1/2inch.
2. Flexible and Liquid-Tight Flexible Conduit: 1/2inch for all runs.
3. MC Cable: 3/8 inch to under-cabinet luminaires, 1/2inch for all other runs.
4. Underground or Concrete Encased Nonmetallic Conduit: 3/4inch for all runs.
5. Conduits used for home runs shall contain only the conductors for the circuits indicated on the drawings. Combining multiple home runs into a single conduit will not be permitted.
6. All fire alarm system conduit shall be 3/4", minimum.

## 2.8 RACEWAY SEALING COMPOUND:

A. Non-hardening, safe for human skin contact, not deleterious to cable insulation, workable at temperatures as low as 35 deg F (1 deg C), withstands temperature of 300 deg F (149 deg C) without slump, and adheres to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials and the common metals.

## PART 3 - EXECUTION

### 3.1 INSPECTION:

- A. Examine areas and conditions under which raceways are to be installed, and substrate which will support raceways. Notify Contractor in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

### 3.2 CONDUIT SCHEDULE:

- A. Buried Raceways: PVC Coated rigid steel galvanized conduit or Schedule 40 or 80 rigid PVC plastic conduit. All underground/buried 90deg ELLS shall be rigid type fittings.
- B. Raceways embedded in concrete slabs or walls in contact with earth: Schedule 40, PVC plastic conduit. PVC coated rigid steel galvanized conduit, OR PVC coated intermediate metal conduit.
- C. Raceways embedded in concrete slabs above grade level: Rigid steel galvanized conduit or Schedule 40 or 80 rigid PVC plastic conduit in slab.
- D. Raceways Penetrating Through Foundation Walls, Below Grade: One 10 foot section of PVC coated rigid steel galvanized, extending from 1 foot inside the foundation wall.
- E. Hazardous areas: Rigid steel galvanized conduit.
- F. Raceways in locations subject to mechanical injury: Rigid steel galvanized conduit OR intermediate metal conduit. Locations subject to mechanical injury include, but are not limited to, the following:
  - 1. Exposed conduits outdoors.
  - 2. Exposed conduits in dock areas and high/medium bay locations up to 25 feet above finished floor.
  - 3. Exposed conduits in parking garages.
  - 4. Exposed conduits in a Fire Pump Room.
  - 5. Exposed feeder and control conduits from engine generators to distribution equipment.
  - 6. Exposed service entrance feeders.

- G. Motor and equipment connections: Flexible metal conduit or PVC jacketed liquid-tight flexible metallic conduit with liquid tight connectors.
- H. Raceways in all other areas shall be electrical metallic tubing unless otherwise noted.
- I. Use flexible metal conduit inside movable partition wireways, from junction boxes to devices and between devices in casework, from outlet boxes to recessed luminaires, and for "fishing" of existing walls. Metal flex allowed only in unoccupied space less than 3 ft.
- J. Under raised computer floor: Jacketed liquid-tight flexible metallic conduit with liquid tight connectors. Jacket shall be rated for plenum application.
- K. Emergency Circuits: All emergency circuits shall be run totally in metal conduit and shall be in a completely separate raceway system from non-emergency circuits.
- L. Rework or extensions of existing conduit shall include the use of similar materials to the existing conduit type unless otherwise noted.

### 3.3 INSTALLATION OF CONDUITS:

- A. General: Install electrical raceways in accordance with manufacturer's written installation instruction, applicable requirements of NEC, and as follows:
  - 1. Conceal conduit unless indicated otherwise, within finished walls, ceilings and floors. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot water pipes. Install raceways level, square and at proper elevations. Exposed conduit shall be mounted flush to building surfaces.
  - 2. Elevation of Raceway:
    - a. Where horizontal raceway is installed near water and steam piping, route raceway above piping and as close to structure as possible and practical.
    - b. Route raceway as close to structure as possible.
  - 3. Complete installation of electrical raceways before starting installation of conductors within raceways.
  - 4. Provide supports for raceways as specified elsewhere in Division 26. When mounting overhead to concrete surfaces, use only steel anchors, without plastic or lead components.
  - 5. Prevent foreign matter from entering raceways by using temporary closure protection.

6. Protect stub-ups from damage where conduits rise from floor slabs. Arrange so curved portion of bend is not visible above the finished slab.
7. Make bends and offsets so the inside diameter is not effectively reduced. Unless otherwise indicated, keep the legs of a bend in the same plane and the straight legs of offsets parallel. Bends in conduit larger than 1-1/4 inch shall be factory-made elbows unless otherwise specifically approved. Bends in 1-1/4 inch and 1 inch runs shall be made in an approved bending machine or factory made. Hickey bends will not be permitted in conduits larger than 3/4 inch.
8. Use raceway fittings that are types compatible with the associated raceway and suitable for the use and location. Install expansion fittings across all structural construction joints and expansion/deflection couplings across all structural expansion joints and in every 200 foot of linear conduit run. A flexible bonding jumper at least three-times the nominal width of the joint shall be installed.
9. Run raceways parallel and perpendicular to building elements and other equipment with a minimum of bends in the shortest practical distance considering the type of building construction and obstructions except as otherwise indicated.
10. Raceways embedded in slabs (Allowed only by written authorization of Structural Engineer/Architect): Install with a minimum of bends, in the shortest practical distance, in middle third of the slab thickness where practical, and leave at least 1 inch concrete cover. Tie raceways to reinforcing rods or otherwise secure them to prevent sagging or shifting during concrete placement. Space raceways laterally to prevent voids in the concrete. Run conduit larger than 1-inch trade size, parallel with or at right angles to the main reinforcement; where at right angles to the reinforcement, the conduit shall be close to one of the supports of the slab. Where nonmetallic conduit is used, raceways must be converted to PVC coated rigid steel conduit before rising above floor.
11. Install exposed raceways parallel and perpendicular to nearby surfaces or structural members and follow the surface contours as much as practical.
12. Install vertical feeder conduits in exterior walls, core walls, or chase spaces. Do not install in interior wall partition areas.
13. Run exposed and parallel raceways together. Make bends in parallel runs from the same center line so that the bends are parallel. Factory elbows may be used only where they can be installed parallel. In other cases provide field bends for parallel raceways.
14. Make raceway joints and terminations tight. Where joints cannot be made tight, use bonding jumpers to provide electrical continuity of the raceway system. Where terminations are subject to vibration, use bonding bushings or wedges to assure electrical continuity. Where subject to vibration or dampness, use insulating bushings to protect conductors.



- Joints in non-metallic conduits shall be made with solvent cement in strict accordance with manufacturer's recommendations.
15. Tighten set screws of threadless fittings with suitable tool.
  16. Terminations: Where raceways are terminated with locknuts and bushings, align the raceway to enter squarely and install the locknuts with dished surface against the box. RGC and IMC shall be secured with double locknuts and an insulated metallic bushing. EMT shall be secured with one locknut and shall have nylon insulated throats or threaded nylon bushings from 1/2" to 1". 1-1/4" and above shall be metal with nylon insulated throats. Use grounding type bushings for feeder conduits at switchboards, panelboards, pull boxes, transformers, motor control centers, VFD's, etc.
  17. Where terminating in threaded hubs, screw the raceway or fitting tight into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align the raceway so the coupling is square to the box, and tighten the chase nipple so no threads are exposed.
  18. Provide nylon pull string with printed footage indicators having not less than 200 pounds tensile strength. Leave not less than 12 inches of slack at each end of the pull string. Identify with tags at each end the origin and destination of each empty conduit and indicate same on all empty or spare conduits on the as-built drawings.
  19. Telephone and Signal System Raceways: Install raceways with maximum lengths at 100 feet and with a maximum of two, 90 degree, radiused bends or equivalent. Install 2' x 2' pull boxes where necessary to comply with these requirements. Install long sweep bends for all data and voice raceways.
  20. Install raceway sealing fittings in accordance with the manufacturer's written instructions. Locate fittings at suitable, approved, 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 and elsewhere as indicated:
    - a. Where conduits enter or leave hazardous locations.
    - b. Where conduits pass from warm locations to cold locations, such as the boundaries of refrigerated spaces and air-conditioned spaces.
    - c. Where conduits enter through a foundation wall or stub-up through a slab on grade floor.
    - d. Where required by the NEC.

21. Install raceway/duct sealing compound inside of all underground stub into a building through a foundation wall or through a slab on grade floor.
22. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment with an adjustable top or coupling threaded inside for plugs and set flush with the finished floor. Extend conductors to equipment with rigid steel conduit; flexible metal conduit may be used 6 inches above the floor. Where equipment connections are not made under this contract, install screwdriver-operated threaded plugs flush with floor.
23. Flexible Connections: Use short length (maximum of 6 feet) of flexible conduit for recessed and semi-recessed luminaires, for equipment subject to vibration, noise transmission, or movement; and for all motors. Use liquid-tight flexible conduit in wet locations. Install separate ground conductor across flexible connections.
24. PVC externally coated rigid steel conduit: Patch all nicks and scrapes in PVC coating after installing conduit.
25. Where conduits are to be installed through structural framing members, the Contractor shall provide sleeves. The Architect/Engineer's written approval must be obtained prior to cutting, notching or drilling of structural framing members.
26. Ream the ends of all cut and/or threaded conduit. Ends shall be cut square.
27. Use of running threads for rigid or intermediate metallic conduit are not permitted. When threaded couplings cannot be used, provide 3-piece union or solid coupling.
28. Route conduit through roof openings for piping and ductwork where possible; otherwise, rout through jack with pitch pocket.
29. Conduit stub-ups from below grade or thru the slab shall be PVC coated rigid steel galvanized conduit and shall extend 6 inches above grade.
30. Wherever conduits enter a structure through a foundation or basement wall below grade, grout around the conduit with water-proof grout or install entrance seals. Seals shall be OZ Type WS or approved equivalent for new construction and OZ type CSM Series for existing structures.
31. Conduits shall not cross pipe shafts or ventilation duct openings. Where conduits must penetrate air-tight spaces or plenums, seal around the conduit with mastic acceptable to the Architect/Engineer.
32. Install an insulated ground conductor in all conduits.
33. Where individual conduits penetrate existing fire-rated walls and floors, pack void around conduit with fire rated insulation and seal opening around conduit with UL

- listed form silicone elastomer compound. Where conduits penetrate exterior walls, new floors, or roof, provide pipe sleeve one size larger than conduit, pack void around conduit with fire rated insulation, and seal opening around conduit with UL listed foam silicone elastomer compound. Conduits on trapeze type support system shall require fire taping only.
34. Where conduit sleeves penetrate fire rated floors or walls for installation of system cables, AC or MC cables, or modular wiring cables pack void around cables or empty sleeve with fire-rated insulation and fill ends with fire-resistive compound. Seal opening around sleeve with UL listed foam silicone elastomer compound.
  35. Use PVC-coated rigid steel factory elbows for bends in plastic conduit runs longer than 100 feet, or in plastic conduit runs which have more than two bends regardless of length. Use long sweep bends for wiring larger than 350 MCM.
  36. Wipe plastic conduit clean and dry before joining. Apply a full, even coat of cement to entire area that will be inserted into fitting. Let joint cure for 20 minutes minimum.
  37. No PVC conduit shall be run exposed or inside stud or masonry walls unless specifically called for on the drawings. Transition from PVC to metal conduit shall be made below grade.
  38. Provide separate raceway systems for each of the following:
    - a. Lighting
    - b. Power Distribution
    - c. Communications and Data
    - d. Emergency (when Emergency Power Generator is utilized)
    - e. UPS (when shown on Construction Documents as a system)
    - f. Fire Alarm
    - g. Temperature Control
    - h. Paint new exposed conduits to match existing exposed conduits where installed in areas with existing painted conduits or where otherwise indicated.
  39. Provide rebar and tie downs for all conduits and conduit racks to be installed with concrete or slurry to prevent conduit "float".
  40. Minerallac, or "minis", shall not be used on conduit installations; 1-hole or 2-hole supports only.

B. Install buried electrical line warnings per Section 26 05 53 “Electrical identification”.

C. Install labeling as required in Section 26 05 53 “Electrical Identification”.

### 3.4 INSTALLATION OF SURFACE RACEWAYS AND WIREWAYS:

A. Surface Raceways and Wireways: Mechanically assemble metal enclosures and raceways to form continuous electrical conductor and connect to electrical boxes, fittings and cabinets as to provide effective electrical continuity and rigid mechanical assembly.

1. Where practicable, avoid use of dissimilar metals throughout system to eliminate possibility of electrolysis. Where dissimilar metals are in contact, coat all surfaces with corrosion inhibiting compound before assembling.
2. Install expansion fittings in all raceways wherever structural expansion joints are crossed.
3. Make changes in direction of raceway run with proper fittings, supplied by raceway manufacturer. Field bends of raceway sections are not permitted.
4. Properly support and anchor raceways for their entire length by structural materials. Raceways are not to span any space unsupported.
5. Use boxes as supplied by raceway manufacturer wherever junction, pull or device boxes are required. Standard electrical "handy" boxes, etc., are not permitted for use with surface raceway installations.
6. Install an insulated grounding conductor in all wireways and surface raceways. Bond grounding conductor to all wireways and surface raceways.
7. Paint new exposed surface metal raceway to match adjacent surfaces where raceway is installed in finished areas such as lobbies, corridors, and normally occupied spaces.
8. Surface raceways and wireways are acceptable only where specifically indicated on the drawings. The proposed use of surface raceways and wireways shall be submitted for review by the Engineer prior to installation.
9. Common wireways are not acceptable for convergence of multiple circuits unless specifically indicated on the drawings. The proposed use of a common wireway shall be submitted for review by the Engineer prior to installation.
10. The proposed use of wireways above or below panelboards, switchboards, motor control centers, and other electrical equipment shall be submitted along with a layout drawing for review by the Engineer prior to installation.

11. Surface metal raceways shall be Wiremold 700 Series or equivalent. Manufacturer's other than Wiremold 700 Series (preferred) or Walker shall be approved by the LPS Operations, Maintenance and Construction (OMC) Department.

### 3.5 ELECTRICAL PROVISIONS FOR ROOF PENETRATIONS:

- A. Raceways penetrating the roof structure shall be installed in a manner to preserve the integrity of the roof. Provide flashing and counter flashing for all roof penetrations required for the work.
- B. Conduits routed above the roof shall be installed a minimum of twelve (12) inches above the finished roof surface, supported on and secured to metal stands installed with flashing and counter flashing, with maximum spacing 8'-0" on center. Coordinate with LPS Division 7 roofing specification sections.
- C. Provide weatherproof GFCI duplex receptacle within 25'-0" of all roof top equipment.
- D. Provide steel fittings and support properly using Miro Industries conduit supports, sized and spaced per manufacturer's recommendations and LPS roofing specification.
  1. Frame style roof stands are not an acceptable means of support. Fabrications may be submitted for LPS OMC Department approval. All roof penetrations shall be approved by the OMC Department prior to installation.

### 3.6 ADJUSTING AND CLEANING:

- A. Upon completion of installation of raceways, inspect interiors of raceways; clear all blockages and remove burrs, dirt and construction debris.

**END OF SECTION 26 05 33.13**

**SECTION 26 05 33.16 - CABINETS, BOXES, AND FITTINGS****PART 1 - GENERAL****1.1 SUMMARY:**

- A. This section includes cabinets, boxes, and fittings for electrical installations and certain types of electrical fittings not covered in other sections. Types of products specified in this Section include:
  - 1. Outlet and device boxes.
  - 2. Pull and junction boxes.
  - 3. Floor boxes and service fittings.
  - 4. Cabinets.
  - 5. Hinged door enclosures.
  - 6. Boxes and fittings for hazardous locations.
  
- B. Conduit-body-type electrical enclosures and wiring fittings are specified in the Section 26 05 13.33 on Raceways.

**1.2 DEFINITIONS:**

- A. Cabinets: An enclosure designed either for surface or for flush mounting and having a frame, or trim in which a door or doors may be mounted.
- B. Device Box: An outlet box designed to house a receptacle device or a wiring box designed to house a switch.
- C. Enclosure: A box, case, cabinet, or housing for electrical wiring or components.
- D. Hinged Door Enclosure: An enclosure designed for surface mounting and having swinging doors or covers secured directly to and telescoping with the walls of the box.
- E. Outlet Box: A wiring enclosure where current is taken from a wiring system to supply utilization equipment.
- F. Wiring Box: An enclosure designed to provide access to wiring systems or for the mounting of indicating devices or of switches for controlling electrical circuits.

**1.3 SUBMITTALS:**

- A. Submit product data for cabinets and enclosures with classification higher than NEMA 1.
- B. Shop drawings for floor boxes and boxes, enclosures and cabinets that are to be shop fabricated, (nonstock items). For shop fabricated junction and pull boxes, show accurately scaled views and spatial relationships to adjacent equipment. Show box types, dimensions, and finishes.

**PART 2 - PRODUCTS****2.1 MANUFACTURERS:**

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
  - 1. Floor Boxes (poke-through style, only, are acceptable):
    - a. Hubbell
    - b. Wiremold
    - c. American Electric.
    - d. Butler Mfg. Co.
    - e. Cooper Industries, Inc.
    - f. Raco, Inc.
    - g. Thomas & Betts Corp.
  - 2. Cabinets:
    - a. General Electric
    - b. Siemens/ITE
    - c. Square D
    - d. Westinghouse
    - e. Hoffman Engineering Co.
    - f. Erickson Electrical Equipment Co.
    - g. Electric Panelboard, Inc.
    - h. Parker Electrical Mfg. Co.
    - i. Spring City Electrical Mfg. Co.

**3. Boxes and Fittings for Hazardous Locations:**

- a. Hubbell
- b. Wiremold
- c. OZ/Gedney.
- d. Cooper Industries, Inc.
- e. Killark Electric Mfg. Co.
- f. Adalet-PLM.
- g. Robroy Industries, Inc.
- h. Spring City Electrical Mfg. Co.
- i. Appleton

**2.2 CABINETS, BOXES, AND FITTINGS, GENERAL:**

- A. Electrical Cabinets, Boxes, and Fittings: Of indicated types, sizes, and NEMA enclosure classes. Where not indicated, provide units of types, sizes, and classes appropriate for the use and location. Provide all items complete with covers and accessories required for the intended use. Provide gaskets for units in damp or wet locations.

**2.3 MATERIALS AND FINISHES:**

- A. Sheet Steel: Flat-rolled, code-gauge, galvanized steel.
- B. Fasteners for General Use: Corrosion resistant screws and hardware including cadmium and zinc plated items.
- C. Fasteners for Damp or Wet Locations: Stainless steel screws and hardware.
- D. Cast Metal for Boxes, Enclosures, and Covers; Copper-free aluminum except as otherwise specified.
- E. Exterior Finish: Gray baked enamel for items exposed in finished locations except as otherwise indicated.
- F. Painted Interior Finish: Where indicated, white baked enamel. Emergency system cabinets and boxes shall be red.
- G. Fittings for Boxes, Cabinets, and Enclosures: Conform to UL 514B. Malleable iron or zinc plated steel for conduit hubs, bushings and box connectors.

**2.4 METAL OUTLET, DEVICE, AND SMALL WIRING BOXES:**



- A. General: Conform to UL 514A, "Metallic Outlet Boxes, Electrical," and UL 514B, "Fittings for Conduit and Outlet Boxes." Boxes shall be of type, shape, size, and depth to suit each location and application. Single gang "handy" boxes shall not be used on any project.
  - B. Steel Boxes: Conform to NEMA OS 1, "Sheet Steel Outlet Boxes, Device Boxes, Covers, and Box Supports." Boxes shall be sheet steel with stamped knockouts, threaded screw holes and accessories suitable for each location including mounting brackets and straps, cable clamps, exterior rings and fixture studs.
  - C. Cast-Aluminum Boxes: Copper free aluminum threaded raceway entries, and features and accessories suitable for each location including mounting ears, threaded screw holes for devices and closure plugs.
  - D. Malleable or Cast-Iron Boxes: Iron alloy, waterproof, with threaded raceway entries and features and accessories suitable for each location, including mounting ears, threaded screw holes for devices and closure plugs.
  - E. Malleable or Cast-Iron Floor Boxes: Fully adjustable, waterproof, with threaded raceway entrances, adjusting rings, gaskets, and brass floor plates. Where indicated, provide multi-section boxes with individual hinged section covers. Provide for power, data, and communication outlets as indicated on the drawings.
  - F. Steel Floor Boxes: Sheet steel, concrete tight, fully adjustable, with stamped knockouts, adjusting rings, and brass floor plates. Where indicated, provide multi-section boxes with concealed individual section covers under a common flush floor plate. Provide for power, data, and communication outlets as indicated on the drawings.
  - G. Service Fittings for Floor Outlet Boxes: Surface mounted horizontal, cast aluminum type 3-inches high, suitable for finished spaces and finished in satin aluminum, except as otherwise indicated. Provide duplex receptacle or 1-inch bushed opening for telephone or other communications service as indicated. Equip fitting for attaching flat to floor box cover.
  - H. Concealed Service Floor Box: Malleable, cast iron, or steel floor boxes as specified above designed to deliver power, data, and communications services from outlets concealed within the box and accessible through a single hinged cover. The cover shall fit into the top of the floor box and include a carpet or tile floor flange, a hinged steel reinforced floor plate with provision for mounting a piece of carpet or tile, and a small retractable cable exit. Provide for power, communications, and data outlets as indicated on the drawings.
- 2.5 NONMETALLIC OUTLET, DEVICE, AND SMALL WIRING BOXES:
- A. General: Conform to NEMA OS 2, "Nonmetallic Outlet Boxes, Device Boxes, Covers, and Box Supports" and UL 514C, "Nonmetallic Outlet Boxes, Flush Device Boxes and

Covers." Boxes shall be molded PVC units of type, shape, size, and depth to suit location and application.

- B. Boxes for Concealed Work: Mounting provisions and wiring entrances to suit installation conditions and wiring method used.
- C. Boxes for Exposed Work: Ultra-violet stabilized, nonconductive, high impact-resistant boxes with integrally molded raceway entrance hubs and removable mounting flanges. Boxes shall be equipped with threaded screw holes for device and cover plate mounting. Each box shall have a molded cover of matching PVC material suitable for the application.

#### 2.6 PULL AND JUNCTION BOXES:

- A. General: Comply with UL 50, "Electrical Cabinets and Boxes", for boxes over 100 cubic inches volume. Boxes shall have screwed or bolted on covers of material same as box and shall be of size and shape to suit application.
- B. Steel Boxes: Sheet steel with welded seams. Where necessary to provide a rigid assembly, construct with internal structural steel bracing.
- C. Hot-Dipped Galvanized Steel Boxes: Sheet steel with welded seams. Where necessary to provide a rigid assembly, construct with internal structural steel bracing. Hot-dip galvanized after fabrication. Cover shall be gasketed.
- D. Stainless-Steel Boxes: Fabricate of stainless steel conforming to Type 302 of ASTM A 167, "Specification for Stainless and Heat Resisting Chromium-Nickel Steel Plate, Sheet, and Strip." Where necessary to provide a rigid assembly, construct with internal structural stainless steel bracing. Cover shall be gasketed.
- E. Cast-Aluminum Boxes: Molded of copper free aluminum, with gasketed cover and integral threaded conduit entrances.
- F. Malleable or Cast-Iron Boxes: Molded of iron alloy with gasketed cover and integral threaded conduit entrances.
- G. Boxes Approved for Classified Locations: Cast metal boxes conforming to UL 886, "Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations," listed and labeled for use in the specific location classification, and with the specific hazardous material encountered. Conduit entrances shall be integral threaded type.

#### 2.7 CABINETS:

- A. Comply with UL 50, "Electrical Cabinets and Boxes."

- B. Construction: Sheet steel, NEMA 1 class except as otherwise indicated. Cabinet shall consist of a box and a front consisting of a one piece frame and a hinged door. Arrange door to close against a rabbet placed all around the inside edge of the frame, with a uniformly close fit between door and frame. Provide concealed fasteners, not over 24 inches apart, to hold fronts to cabinet boxes and provide for adjustment. Provide flush or concealed door hinges not over 24 inches apart and not over 6 inches from top and bottom of door. For flush cabinets, make the front approximately 3/4 inch larger than the box all around. For surface mounted cabinets make front same height and width as box.
- C. Doors: Double doors for cabinets wider than 24 inches. Telephone cabinets wider than 48 inches may have sliding or removable doors.
- D. Locks: Combination spring catch and key lock, with all locks for cabinets of the same system keyed alike. Locks may be omitted on signal, power, and lighting cabinets located within wire closets and mechanical-electrical rooms. Locks shall be of a type to permit doors to latch closed without locking.

#### 2.8 STEEL ENCLOSURES WITH HINGED DOORS:

- A. Comply with UL 50, "Cabinets and Enclosures" and NEMA ICS 6, "Enclosures for Industrial Controls and Systems."
- B. Construction: Sheet steel, 16 gage, minimum, with continuous welded seams. NEMA class as indicated; arranged for surface mounting.
- C. Doors: Hinged directly to cabinet and removable, with approximately 3/4 inch flange around all edges, shaped to cover edge of box. Provide handle operated, key locking latch. Individual door width shall be no greater than 24 inches. Provide multiple doors where required.
- D. Mounting Panel: Provide painted removable internal mounting panel for component installation.
- E. Enclosure: NEMA 1 except as indicated. Where door gasketing is required, provide neoprene gasket attached with oil-resistant adhesive, and held in place with steel retaining strips. For all enclosures of class higher than NEMA 1, use hubbed raceway entrances.

#### 2.9 CAST METAL ENCLOSURES WITH HINGED DOORS:

- A. Copper free aluminum with bolted, hinged doors. Where used at hazardous (classified) locations, enclosures shall conform to UL and shall be listed and labeled for the classification of hazard involved.

**2.10 MOLDED NONMETALLIC ENCLOSURES WITH HINGED DOOR:**

- A. General: Molded, glass fiber reinforced high impact strength polyester with bolt or screw secured doors and solid neoprene gaskets.

**PART 3 - EXECUTION****3.1 INSTALLATION, GENERAL:**

- A. Locations: Install items where indicated and where required to suit code requirements and installation conditions.
- B. Cap unused knockout holes where blanks have been removed and plug unused conduit hubs.
- C. Support and fasten items securely in accordance with Section 26 05 29 on Supporting Devices.
- D. Sizes shall be adequate to meet NEC volume requirements, but in no case smaller than sizes indicated.
- E. Remove sharp edges where they may come in contact with wiring or personnel.

**3.2 APPLICATIONS:**

- A. Cabinets: Flush mounted, NEMA enclosure type 1 except as otherwise indicated.
- B. Hinged Door Enclosures Indoor: NEMA type 1 enclosure except as indicated.
- C. Hinged Door Enclosures Outdoors: NEMA Type 4. Install drip hood, factory tailored to individual units.
- D. Hinged Door Enclosures in Corrosive Locations: NEMA type 4X nonmetallic enclosure.
- E. Outlet Boxes and Fittings: Install outlet and device boxes and associated covers and fittings of materials and NEMA types suitable for each location and in conformance with the following requirements:
  - 1. Interior Dry Locations: NEMA Type 1, sheet steel or nonmetallic as permitted by local code.
  - 2. Locations Exposed to Weather or Dampness: Cast metal, NEMA type 3R.
  - 3. Wet Locations: NEMA Type 4 enclosures.

4. Corrosive Locations: NEMA Type 4X enclosures.
  5. Hazardous (Classified) Locations: NEMA type listed and labeled for the location and class of hazard indicated.
- F. Pull and Junction Boxes: Install pull and junction boxes of materials and NEMA types suitable for each location except as otherwise indicated.
- G. Floor Boxes: In slabs on grade and wet locations use NEMA type 4 boxes. At other locations in slabs, use concrete-tight NEMA 1 boxes.

### 3.3 INSTALLATION OF OUTLET BOXES:

- A. Outlets at Windows and Doors: Locate close to window trim. For outlets indicated above doors center outlets above the door opening except as otherwise indicated.
- B. Column and Pilaster Locations: Locate outlet boxes for switches and receptacles on columns or pilasters so the centers of the columns are clear for future installation of partitions.
- C. Locations in Special Finish Materials: For outlet boxes for receptacles and switches mounted in desks or furniture cabinets or in glazed tile, concrete block, marble, brick, stone or wood walls, use rectangular shaped boxes with square corners and straight sides. Install such boxes without plaster rings. Saw cut all recesses for outlet boxes in exposed masonry walls.
- D. Gasketed Boxes: At the following locations use malleable or cast metal, threaded hub type boxes with gasketed weatherproof covers:
1. Exterior locations.
  2. Where surface mounted on unfinished walls, columns or pilasters. (Cover gaskets may be omitted in dry locations).
  3. Where exposed to moisture laden atmosphere.
  4. At food preparation equipment within four feet of steam connections.
  5. Where indicated.
- E. Mounting: Mount outlet boxes for switches with the long axis vertical or as indicated. Mount boxes for receptacles vertically, except above counter receptacles to be mounted horizontally. Three or more gang boxes shall be mounted with the long axis horizontal. Locate box covers or device plates so they will not span different types of building finishes

either vertically or horizontally. Locate boxes for switches near doors on the side opposite the hinges and close to door trim, even though electrical floor plans may show them on hinge side. Provide far side box supports, for electrical switch boxes installed on metal studs and provide stud to stud support for electrical receptacle boxes installed on metal studs.

- F. Ceiling Outlets: For fixtures, where wiring is concealed, use outlet boxes 4 inches square by 1-1/2 inches deep, minimum.
- G. Cover Plates for Surface Boxes: Use plates sized to box front without overlap.
- H. Protect outlet boxes to prevent entrance of plaster, and debris. Thoroughly clean foreign material from boxes before conductors are installed.
- I. Concrete Boxes: Use extra deep boxes to permit side conduit entrance without interfering with reinforcing, but do not use such boxes with over 6 inch depth.
- J. Floor Boxes: Poke-through style, only, are acceptable.
- K. Existing Outlet Boxes: Where extension rings are required to be installed, drill new mounting holes in the rings to align with the mounting holes on the existing boxes where existing holes are not aligned.
- L. Back to back outlet boxes are not permitted. Separate boxes a minimum of 6 inches in standard walls and 24 inches in acoustical walls.

**3.4 INSTALLATION OF PULL AND JUNCTION BOXES:**

- A. Box Selection: For boxes in main feeder conduit runs, use sizes not smaller than 8 inches square by 4 inches deep. Do not exceed 6 entering and 6 leaving raceways in a single box. Quantities of conductors (including equipment grounding conductors) in pull or junction box shall not exceed the following:

<u>Size of Largest</u>	<u>Maximum no. of</u>
<u>Conductors in Box</u>	<u>Conductors in Box</u>
No. 4/0 AWG	30
250 MCM	20
500 MCM	15
Over 500 MCM	10

- B. Cable Supports: Install clamps, grids, or devices to which cables may be secured. Arrange cables so they may be readily identified. Support cable at least every 30 inches inside boxes.
- C. Mount pull boxes in inaccessible ceilings with the covers flush with the finished ceiling.
- D. Size: Provide pull and junction boxes for telephone, signal, and other systems at least 50 percent larger than would be required by Article 370 of NEC, or as indicated. Locate boxes strategically and provide shapes to permit easy pulling of future wires or cables of types normal for such systems.

### 3.5 INSTALLATION OF CABINETS AND HINGED DOOR ENCLOSURES:

- A. Mount with fronts straight and plumb.
- B. Install with tops 78 inches above floor.
- C. Set cabinets in finished spaces flush with walls.

### 3.6 GROUNDING:

- A. Electrically ground metallic cabinets, boxes, and enclosures. Where wiring to item includes a grounding conductor, provide a grounding terminal in the interior of the cabinet, box or enclosure.

### 3.7 CLEANING AND FINISH REPAIR:

- A. Upon completion of installation, inspect components. Remove burrs, dirt, and construction debris and repair damaged finish including chips, scratches, abrasions and weld marks.
- B. Galvanized Finish: Repair damage using a zinc-rich paint recommended by the manufacturer.
- C. Painted Finish: Repair damage using matching corrosion inhibiting touch-up coating.

**END OF SECTION 26 05 33.16**

**SECTION 26 05 36 - CABLE TRAYS****PART 1 - GENERAL****1.1 SUMMARY:**

- A. This section includes metallic cable trays. Types of cable trays in this section include the following:
  - 1. Ladder.
  - 2. Trough.
  - 3. Solid Bottom.
  - 4. Channel.

**1.2 DEFINITIONS:**

- A. Refer to NEMA Standard VE 1 for definitions of cable tray terminology used in this section.

**1.3 SUBMITTALS:**

- A. General: Submit the following in accordance with the General Conditions of the Contract and other Division 26 sections:
  - 1. Product Data for cable tray products.
  - 2. Shop Drawings: Layout floor plans and elevations in 1/8" or 1/4" = 1'-0" scale showing cable tray system. Designate components and accessories including clamps, brackets, hanger rods, splice plates connectors, expansion joint assemblies, straight lengths, and fittings. Show accurately scaled components and spatial relationships to adjacent equipment. Show tray types, dimensions, and finishes.

**1.4 QUALITY ASSURANCE:**

- A. Single-Source Responsibility: All cable tray components shall be the product of a single manufacturer.

**1.5 SEQUENCING AND SCHEDULING:**

- A. Coordination Drawings: Include accurately scaled, cable tray systems in coordination with floor plans and sections. Coordinate layout and installation of cable tray with other installations. Revise locations and elevations from those indicated as required to suit field conditions, only as approved by the Architect and Engineer.



**PART 2 - PRODUCTS****2.1 MANUFACTURERS:**

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
  - 1. B-Line Systems, Inc.
  - 2. Globe
  - 3. Husky-Burndy
  - 4. Square D Co.
  - 5. Mono-Systems, Inc.
  - 6. T.J. Cope, Inc.

**2.2 CABLE TRAYS, GENERAL REQUIREMENTS:**

- A. Cable tray systems shall be of indicated types, sizes, and NEMA classes and shall be complete with manufacturer's recommended covers, barrier strips, dropouts, fittings, conduit adapters, hold-down devices, grommets, and blind ends as required and indicated.
- B. Cable tray products shall have rounded edges and smooth surfaces.
- C. Steel hardware to be protected against corrosion by galvanizing conforming to ASTM B 633 or cadmium plating conforming to ASTM B 766.

**2.3 MATERIALS AND FINISHES:**

- A. Cable Trays, Fittings, and Accessories: Steel, mill galvanized before fabrication.
- B. Cable Trays, Fittings, and Accessories: Stainless steel, Type 304.

**2.4 SIZES AND CONFIGURATIONS:**

- A. Ladder-Type Trays: Class 20C unless indicated.
  - 1. Cross-Rung Spacing: 6 inches o.c.  
Cross-Rung Spacing: 9 inches o.c.  
Cross-Rung Spacing: 12 inches o.c.  
Cross-Rung Spacing: 18 inches o.c.

2. Inside Depth: 3 inches.

Inside Depth: 4 inches.

Inside Depth: 5 inches.

Inside Depth: 6 inches.

3. Width: 6 Inches

Width: 12 Inches

Width: 18 Inches

Width: 24 Inches

Width: 30 Inches

Width: 36 Inches

4. Minimum Fitting Radius: 12 inches.

Minimum Fitting Radius: 24 inches.

Minimum Fitting Radius: 36 inches.

B. Trough-Type Trays: Class 20C unless indicated.

1. Inside Depth: 3 inches.

Inside Depth: 4 inches.

Inside Depth: 5 inches.

Inside Depth: 6 inches.

2. Width: 6 Inches

Width: 12 Inches

Width: 18 Inches

Width: 24 Inches

Width: 30 Inches

Width: 36 Inches

3. Minimum Fitting Radius: 12 inches.

Minimum Fitting Radius: 24 inches.

Minimum Fitting Radius: 36 inches.

C. Solid-Bottom Type Trays: Class 20C unless indicated.

1. Inside Depth: 3 inches.

Inside Depth: 4 inches.

Inside Depth: 5 inches.

Inside Depth: 6 inches.

2. Width: 6 Inches

Width: 12 Inches

Width: 18 Inches

Width: 24 Inches

Width: 30 Inches

Width: 36 Inches

3. Minimum Fitting Radius: 12 inches.

Minimum Fitting Radius: 24 inches.

Minimum Fitting Radius: 36 inches.

**D. Channel-Type Trays:**

1. Width: 3 inches.

Width: 4 inches.

Width: 6 inches.

2. Minimum Fitting Radius: 12 inches.

Minimum Fitting Radius: 24 inches.

Minimum Fitting Radius: 36 inches.

3. Tray Bottom: Ventilated.

Tray Bottom: Nonventilated.

**2.5 CABLE TRAY ACCESSORIES:**

- A. Covers: Louvered type, of same materials and finishes as cable trays.

- B. Fittings: Tees, crosses, risers, elbows and other fittings as indicated, manufactured of same materials and finishes as cable trays.

- C. Barrier Strips: Same materials and finishes as cable trays.

**2.6 SUPPORTS AND CONNECTORS:**

- A. Cable tray supports and connectors, including bonding jumpers shall be as recommended by cable tray manufacturer. Cable tray shall be center supported. All thread supports shall be sleeved to protect cables.

**2.7 WARNING SIGNS:**

- A. Lettering: 1-1/2-inch high, black on yellow background with legend "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL."

**PART 3 - EXECUTION****3.1 INSTALLATION OF CABLE TRAY SYSTEMS:**

- A. Install cable trays in accordance with equipment manufacturer's written instructions.
- B. Remove burrs and sharp edges of cable trays.
- C. Support cable tray independently utilizing the building structural components.
- D. Conform to manufacturer's recommendations for selection and installation of supports.
- E. Strength of each support including fastenings to the structure shall be adequate to carry present and future load multiplied by a safety factor of at least four or 200 lbs, whichever is greater.
- F. Support Locations: Locate supports in accordance with the recommendations of Article 6.6 of NEMA Standard VE 1.
- G. Installation of supports shall be in accordance with cable tray manufacturer's written instructions and the recommendations of Paragraph 6.5 of NEMA Standard VE 1.
- H. Fastening Supports: Unless otherwise indicated, fasten cable tray supports securely to the building structure.
- I. Support at Connections to Equipment: Where cable trays connect to equipment, provide flanged fittings fastened to the tray and to the equipment. Support the tray separately. Do not carry the weight of the tray on the equipment enclosure.
- J. Thermal Contraction and Expansion: Install expansion connectors in cable tray runs that exceed 90 feet. Space connectors and set gaps according to NEMA Standard VE 1.
- K. Direction Changes: Make changes in direction of cable tray with standard cable tray fittings.
- L. Locate cable tray above piping except as required for tray accessibility and as otherwise indicated.
- M. Firestopping: Where cable trays penetrate fire and smoke barriers including walls, partitions, floors, and ceilings, install firestopping at penetrations after cables are installed.
- N. Sleeves For Cables: Where cable trays are not indicated to penetrate fire and smoke barriers as indicated above, install sleeves for cables. Provide 3 inch conduit sleeves for full width of cable tray.
- O. Working Space: Install cable trays with sufficient space to permit access for installing cables. Clear space shall be provided above the top rail equal to the loading depth but not less than 6 inches. Provide lateral clearance of 24 inches on both sides of center hung on one side of wall hung tray.

- P. Barriers: Where trays carry conductors of different systems, such as power, communications, and data processing, or different insulation levels, install barriers to separate the systems.

### 3.2 GROUNDING:

- A. Electrically ground cable trays and ensure continuous electrical conductivity of cable tray system. Use tray as an equipment ground conductor for itself only, not for connected equipment.

### 3.3 WARNING SIGNS:

- A. After installation of cable trays is completed, install warning signs, on or in proximity to cable trays, where easily seen. Signs shall be located on all accessible sides and not greater than 20 feet on center. No section of tray shall be without at least one warning sign per side.

### 3.4 FIELD TESTING:

- A. Grounding: Test cable trays to ensure electrical continuity of bonding and grounding connections.

### 3.5 CLEANING AND FINISH REPAIR:

- A. Upon completion of installation of cable trays, inspect trays, fittings, and accessories. Remove burrs, dirt, and construction debris and repair damaged finish including chips, scratches and abrasions.
- B. Galvanized Finish: Repair damage with a zinc-rich paint recommended by the tray manufacturer.
- C. PVC or Paint Finish: Repair damage with matching touch-up coating recommended by the tray manufacturer.

**END OF SECTION 26 05 36**



**SECTION 26 05 53 - ELECTRICAL IDENTIFICATION****PART 1 - GENERAL****1.1 SUMMARY:**

- A. This Section includes identification of electrical materials, equipment, and installations. It includes requirements for electrical identification components including but not limited to the following:
  - 1. Buried electrical line warnings.
  - 2. Identification labeling for raceways, cables, and conductors.
  - 3. Operational instruction signs.
  - 4. Warning and caution signs.
  - 5. Equipment labels and signs.

**1.2 SUBMITTALS:**

- A. General: Submit the following in accordance with the General Conditions of the Contract and other Division 26 sections.
  - 1. Product Data for each type of product specified.
  - 2. Schedule of identification nomenclature to be used for identification signs and labels for each piece of equipment shall include, but not be limited to, the following equipment types as specified in Division 26.
    - a. Cabinets and enclosures
    - b. Switchboards and Switchgear
    - c. Transformers
    - d. Bus duct
    - e. Panelboards
    - f. Disconnect switches
    - g. Circuit breakers and switches for installation in distribution centers
    - h. Motor control centers



- i. Starters
  - j. Variable frequency drives
  - k. Transfer switches
  - l. Engine generators and all ancillary cabinets and equipment
  - m. Fire alarm system panels and all ancillary cabinets and equipment
  - n. Paging, intercom and background music system cabinets.
  - o. Lighting control cabinets including dimmer cabinets.
  - p. Device cover plates
- 3. Samples of each color, lettering style and other graphic representation required for identification materials; samples of labels and signs.
  - 4. Identification required in this section shall apply to equipment furnished in Division 26 and any other applicable sections in Divisions 20 through 28.
- 1.3 QUALITY ASSURANCE:
- A. ANSI Compliance: Comply with requirements of ANSI Standard A13.1, "Scheme for the Identification of Piping Systems," with regard to type and size of lettering for raceway and cable labels.

**PART 2 - PRODUCTS**

**2.1 MANUFACTURERS:**

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
  - 1. Ideal Industries, Inc.
  - 2. 3M Company
  - 3. Panduit Corp.
  - 4. LEM Products, Inc.
  - 5. Markal Corp.
  - 6. W.H.Brady, Co.

## 2.2 ELECTRICAL IDENTIFICATION PRODUCTS:

- A. Adhesive Marking Labels for Raceway and Busway: Pre-printed, flexible, self-adhesive labels with legend indicating voltage and service (Emergency, Lighting, Power, Power d.c., HVAC, Communications, Control, Fire).
  - 1. Label Size for Raceways and Busway: Kroy or Brother labels 1 inch high by 12 inches long (minimum) with 5/8 inch minimum height letters.
  - 2. Color: As specified for various systems.
- B. Colored Adhesive Marking Tape for banding Raceways, Wires, and Cables: Self-adhesive vinyl tape not less than 3 mils thick by 1 inch to 2 inches in width.
- C. Pre-tensioned Flexible Wraparound Colored Plastic Sleeves for Cable Identification: Flexible acrylic bands sized to suit the cable diameter and arranged to stay in place by pre-tensioned gripping action when coiled around the cable.
- D. Underground Line Marking Tape: Metal-detector detectable, permanent, bright-colored, continuous-printed, plastic tape compounded for direct-burial service not less than 6 inches wide by 4 mils thick. Printed legend indicative of general type of underground line below.
- E. Wire/Cable Designation Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wraparound, cable/conductor markers with preprinted numbers and letter.
- F. Engraved, Plastic-Laminated Labels, Signs and Instruction Plates: Engraving stock melamine plastic laminate, 1/16 inch minimum thick for signs up to 20 square inches, or 8 inches in length; 1/8 inch thick for larger sizes. Engraved legend in white letters on black face for normal and white letters on red face for emergency, black letters on yellow face for UPS and punched for mechanical fasteners. Where required for ground connections, provide engraved legend in white letters on green face.
- G. Baked-Enamel Warning and Caution Signs for Interior Use: Preprinted aluminum signs, punched for fasteners, with colors, legend, and size appropriate to the location.
- H. Exterior Metal-Backed Butyrate Warning and Caution Signs: Weather-resistant, nonfading, preprinted cellulose acetate butyrate signs with 20-gage, galvanized steel backing, with colors, legend and size appropriate to the location. Provide 1/4 inch grommets in corners for mounting.
- I. Fasteners for Plastic-Laminated and Metal Signs: Self-tapping stainless steel screws or number 10/32 stainless steel machine screws with nuts and flat and lock washers.
- J. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking nylon cable ties, 0.18-inch minimum width, 50 lb minimum tensile strength, and suitable for a

temperature range from minus 50 degrees F to 350 degrees F. Provide ties in specified colors when used for color coding.

- K. Adhesive Marking Tape for Device Cover Plates: 3/8 inch Kroy tape or Brother labels with 3/16 inch minimum height letters. Tape shall have black letters on clear background for normal and red letters on clear background for emergency. Embossed Dymo-Tape labels are not acceptable.

## PART 3 - EXECUTION

### 3.1 INSTALLATION:

- A. Lettering and Graphics: Coordinate names, abbreviations, colors, and other designations used in electrical identification work with corresponding designations specified or indicated. Install numbers, lettering, and colors as approved in submittals and as required by code.
- B. Install identification devices in accordance with manufacturer's written instructions and requirements of NEC.
- C. Sequence of Work: Where identification is to be applied to surfaces that require finish, install identification after completion of finish work.
- D. Conduit Identification: Use adhesive marking tape labels to identify all exposed conduits. Conduits located above non-accessible ceiling or in floors and walls shall be labeled within 3 feet of becoming accessible. Labels for multiple conduits shall be aligned and read the same direction. Use the following colors:
  - 1. Above 600 Volts: Black letters on orange background indicating source equipment designation, circuit number (if applicable), and voltage. Alternate identification labels with "DANGER - HIGH VOLTAGE" warning signs of the same color.
  - 2. 600 Volt and Below Normal: White letters on black background indicating source equipment designation, circuit number(s), and voltage.
  - 3. 600 Volt and Below Emergency: White or black letters on red background indicating source equipment designation, circuit number(s), and voltage.
  - 4. Fire Alarm: Red letters on white background indicating "FIRE ALARM".
  - 5. Temperature Control: White or black letters on blue background indicating "TEMP. CONTROL."
  - 6. Ground: White or black letters on green background indicating "GROUND" and equipment and designation.
  - 7. Network Fiber: Black letters on white background indicating "NETWORK FIBER."

8. Where conduits enter or exit a panelboard, pull or junction box, switchboard, or other distribution equipment, conduit labels shall include circuit number in addition to feeder identification and voltage.
- E. Identify Junction, Pull and Connection Boxes: Identification of systems and circuits shall indicate system voltage and identity of contained circuits on outside of box cover. Color code shall be same as conduits for pressure sensitive labels. Use self-adhesive marking tape labels at exposed locations and indelible black marker at concealed boxes. All fire alarm boxes shall have covers painted red. All temperature control boxes shall have covers painted blue.
- F. Underground Electrical Line Identification: During trench backfilling, for exterior underground power, signal and communications lines, install continuous underground plastic line marker, located directly above line at 6 to 8 inches below finished grade. Where multiple lines installed in a common trench or concrete envelope, do not exceed an overall width of 16 inches; install a single line marker. Tape shall be 6 inches wide, 0.004 inches thick and 1750 psi minimum strength, trace wire run continuous length manhole to manhole and to equipment. Provide 3 feet slack rolled at each end.
1. Install line marker for underground wiring, both direct-buried and in raceway. Red for electrical, orange for phone and cable.
- G. Circuit Identification: Tag or label conductors as follows:
1. Future Connections: Conductors indicated to be for future connection or connection under another contract with identification indicating source and circuit numbers.
  2. Multiple Circuits: Where multiple branch circuits, control wiring or communications/signal conductors are terminated or spliced in a box or enclosure, label each conductor or cable with circuit number. For control and communications/signal wiring, use wire/cable marking tape at terminations in wiring boxes, troughs and control cabinets. Use consistent letter/number conductor designations throughout on wire/cable marking tapes.
  3. Match identification markings with designations used in panelboards shop drawings, Contract Documents and similar previously established identification schemes for the facility's electrical installations.
- H. Apply warning, caution and instruction signs and stencils as follows:
1. Install warning, caution or instruction signs where required by NEC, where indicated, or where reasonably required to assure safe operation and maintenance of electrical systems and of the items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions or explanations are needed

- for system or equipment operation. Install butyrate signs with metal backing for outdoor items.
2. Emergency Operating Signs (when applicable): Install, where required by NEC, where indicated, or where reasonably required to assure safe operation and maintenance of electrical systems and of the items to which they connect, engraved laminate signs with white legend on red background with minimum 3/8 inch high lettering for emergency instructions on power transfer, or other emergency operations.
    - a. Provide sign at main service entrance switch, indicating type and location of on-site stand-by generator as required by NEC. Sign shall read “Secondary Source Provided by Engine Generator Located In Room #\_\_\_\_\_”.
- I. Install equipment/system circuit/device identification as follows:
1. Apply equipment identification labels of engraved plastic-laminate on each major unit of electrical equipment in building, including central or master unit of each electrical system. This includes communication/signal/alarm systems, unless unit is specified with its own self-explanatory identification. Text shall match terminology and numbering of the Contract Documents and shop drawings. Apply labels for each unit of the following categories of electrical equipment.
    - a. Panelboards, electrical cabinets and enclosures.
    - b. Access doors and panels for concealed electrical items.
    - c. Electrical switchgear and switchboards.
    - d. Motor control centers.
    - e. Motor starters.
    - f. Pushbutton stations.
    - g. Power transfer equipment.
    - h. Contactors.
    - i. Remote-controlled switches.
    - j. Dimmers.
    - k. Control devices.
    - l. Transformers.
    - m. Power generating units.
    - n. Telephone switching equipment.

- o. Clock/program master equipment.
  - p. TV/audio monitoring master station.
  - q. Fire alarm master station or control panel.
- J. Apply circuit/control/item designation labels of engraved plastic laminate for disconnect switches, breakers, pushbuttons, pilot lights, motor control centers, and similar items for power distribution and control components above, except panelboards and alarm/signal components, where labeling is specified elsewhere.
- K. For panelboards, provide framed, typed circuit schedules (label all spares and spaces in pencil) with explicit description and identification of items controlled by each individual circuit breaker.
- L. Tag all grounding electrode conductors, associated bonding conductors, and C.O. grounding conductors at their point of attachment to any ground bus and grounding electrode (where possible) with a 2 inch diameter round, green phenolic nameplate. Lettering shall be 1/4 inch high with 1/5 inch between lines centered on the tag stating "DO NOT DISCONNECT", "MAIN (OR C.O.) GROUND." Nameplate shall attach to conductor with a short length of small chain.
- M. Install labels at locations as required and at locations for best convenience of viewing without interference with operation and maintenance of equipment.
- N. Provide tape labels for identification of individual receptacle and light switch wallplates. Locate tape on front of plate and identify branch circuit serving the receptacle. Provide tape labels for identification of individual switches or thermal overload switches which serve as equipment disconnects. Locate the tape on the front of the coverplate and identify the branch circuit serving the equipment.

**END OF SECTION 26 05 53**



**SECTION 26 05 83 - ELECTRICAL CONNECTIONS FOR EQUIPMENT****PART 1 - GENERAL****1.1 SUMMARY:**

- A. Extent of electrical connections for equipment is indicated by drawings and schedules. Electrical connections are hereby defined to include connections used for providing electrical power to equipment.
- B. Applications of electrical power connections specified in this section include the following:
  - 1. To resistive heaters.
  - 2. From electrical source to motor starters.
  - 3. From motor starters to motors.
  - 4. To lighting equipment.
  - 5. To converters, rectifiers, transformers, inverters, rheostats, and similar current adjustment features of equipment.
  - 6. To grounds including earthing connections.
  - 7. To master units of communication, signal, alarm, clock, public address, sound, and video systems.
  - 8. Other connections as shown.

**1.2 QUALITY ASSURANCE:**

- A. Manufacturers: Firms regularly engaged in manufacture of electrical connectors and terminals, of types and ratings required, and ancillary connection materials, including electrical insulating tape, soldering fluxes, and cable ties, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Installer's Qualifications: Firms with at least 2 years of successful installation experience with projects utilizing electrical connections for equipment similar to that required for this project.

**1.3 SUBMITTALS:**

- A. Product Data: Submit manufacturer's data on electrical connections for equipment products and materials.



**1.4 DEFINITIONS:****A. Load voltage wiring shall be defined as:**

1. Conduit and wiring required to carry power to motors and other equipment or devices. Wiring from control devices to equipment that carry power to drive that equipment such as line voltage thermostats, etc., shall be included as load voltage wiring. Wiring that provides power to control panels, control transformers, control relays, time clocks, etc., shall also be included as load voltage wiring.

**1.5 DELIVERY, STORAGE, AND HANDLING:**

- A. Deliver electrical connection products wrapped in proper factory fabricated type containers.
- B. Store electrical connection products in original cartons and protect from weather, construction traffic and debris.
- C. Handle electrical connection products carefully to prevent breakage, denting, and scoring finish.

**PART 2 - PRODUCTS****2.1 ACCEPTABLE MANUFACTURERS:**

- A. Manufacturer: Subject to compliance with requirements, provide circuit and motor disconnects by one of the following:
  1. General Electric Co.
  2. Square D Company
  3. Siemens Energy & Automation, Inc.
  4. Westinghouse Electric Corp.
  5. Eaton
  6. Cutler-Hammer Inc.

**2.2 GENERAL:**

- A. Overcurrent Protective Devices (OCPDs): Provide type, rating and features as indicated. Comply with Section 26 28 00 on Overcurrent Protective Devices, with OCPDs adapted to equipment connection installation. Tandem circuit breakers shall not be used. Multiple breakers shall have common trip.

- B. Provide motor controllers that are horsepower rated to suit the motor controlled.
- C. Contacts shall open each ungrounded connection to the motor. Contacts shall be NEMA rated, 75°C.
- D. Overload relays shall be ambient-compensated type with inverse-time-current characteristic. Provide with heaters or sensors in each phase matched to nameplate full load current of the specific motor to which connected, with appropriate adjustment for duty cycle and power factor correction supplied with the motor.

### 2.3 MATERIALS AND COMPONENTS:

- A. General: For each electrical connection indicated, provide complete assembly of materials, including but not necessarily limited to, pressure connectors, terminals (lugs), electrical insulating tape, electrical solder, electrical soldering flux, heat-shrinkable insulating tubing, cable ties, solderless wire-nuts, disconnect, starter, contactor, relays, etc., and other items and accessories as needed to complete splices and terminations of types indicated.
- B. Metal Conduit, Tubing and Fittings:
  - 1. General: Provide metal (steel, only) conduit, tubing and fittings of types, grades, sizes and weights (wall thicknesses) indicated for each type service. Provide products complying with Division 26 section on Raceways.
- C. Wires, Cables, and Connectors:
  - 2. General: Provide wires, cables and connectors complying with Division 26 sections on Wires and Cables.
  - 3. Wires/Cables: Unless otherwise indicated, provide wires/cables (conductors) for electrical connections which match, including sizes, ratings, and material of wires/cables which are supplying electrical power.
  - 4. Connectors and Terminals: Provide electrical connectors and terminals which mate and match, including sizes and ratings, with equipment terminals and are recommended by equipment manufacturer for intended applications.
  - 5. Electrical Connection Accessories: Provide electrical insulating tape, heat-shrinkable insulating tubing and boots, electrical solder, electrical soldering flux, wirenuts and cable ties as recommended for use by accessories manufacturers for type services indicated.
  - 6. Cord and Plug Connected Equipment: Where indicated, contractors shall provide a length of SO cord complete with a straight blade or twist-lock receptacle for connection of equipment. Cord and plug rating shall be suitable for the connected equipment load and rating of the branch circuit overcurrent protective device. Plug shall match

receptacle configuration included on the plans and cord length shall be as required. Contractor shall connect cord to equipment.

#### 2.4 MANUAL MOTOR STARTERS:

- A. Manual starters shall be flush-mounting type except where conduits are run exposed or as otherwise noted. Manual starters shall be complete with properly sized overload protection and neon pilot light. Manual starters shall be Square D Class 2510 or Allen-Bradley Bulletin 600 with stainless steel plates.
- B. Motor starter shall have a spare set of auxiliary N.O. and N.C. contacts supplied with starter.
- C. Heater units in all manual motor starters shall be sized for approximately 115 percent of full load motor current. Check and coordinate all thermal protective devices with the equipment they protect.

#### 2.5 CIRCUIT AND MOTOR DISCONNECT SWITCHES:

- A. General: Provide circuit and motor disconnect switches in types, sizes, duties, features, ratings and enclosures as indicated. All equipment with maximum fuse size listed in nameplate shall have fusible disconnect switch provided. Provide NEMA 1 enclosure. For outdoor switches and switches indicated as weatherproof, provide NEMA 3R enclosures with rain-tight hubs. For motor and motor starter disconnects, provide units with horsepower ratings suitable to the loads.
- B. Fusible Switches: Heavy duty switches, with fuses of classes and current ratings indicated. Where current limiting fuses are indicated, provide switches with non-interchangeable feature suitable only for current limiting type fuses. All disconnect switches shall be fusible unless otherwise noted. Provide UL type "HD" 100 percent duty rated switches.
- C. Non-fusible Disconnects: Heavy duty switches of classes and current ratings as indicated. Provide UL type "HD" 100 percent duty rated switches.
- D. Double-Throw Switches: Heavy duty switches of classes and current ratings as indicated.
- E. Switches for Classified (Hazardous) Locations: Heavy duty switches, with UL labels and listings for hazardous location classifications in which installed.
- F. Accessories:
  - 1. Electrical Interlocks: Provide number and arrangement of interlock contacts in switches as indicated or required.
  - 2. Special Enclosure Material: Provide special enclosure material as follows for switches indicated:

- a. Stainless Steel Type 304: For NEMA Type 4.
  - b. Molded Fiberglass Reinforced Plastic: For NEMA Type 4x.
  - c. Heavy Cast Aluminum: For hazardous locations. NEMA Types 7 through 9.
3. Handles shall be lockable in open and closed position without modification.

## 2.6 AUXILIARY CONTROL DEVICES:

- A. General: Provide the following factory installed in controller enclosure except as otherwise indicated. Where separately mounted, provide NEMA 1 enclosure except as otherwise indicated.
1. Pushbutton Stations, Pilot Lights, and Selector Switches: Heavy-duty type. HAND-OFF-AUTOMATIC (H-O-A) switches shall be provided on all magnetic starters. Provide magnetic two-speed starters with a HIGH-LOW selector with H-O-A switch wired to allow manual speed selection in HAND position and remote speed selection in AUTO.
  2. Stop and Lockout Pushbutton Station: Momentary-break pushbutton station with a factory-applied hasp arranged so a padlock can be used to lock the pushbutton in the depressed position with the control circuit open.
  3. Control Relays: Auxiliary and adjustable time-delay relays as required to coordinate with Divisions 23 through 25 Controls sections.
  4. Elapsed Time Meters: Heavy duty with digital readout in hours. Provide on all magnetic starters for motors.
  5. Ammeters, Voltmeters, and Frequency Meters: Panel type, 2-1/2 inch minimum size with 90 degree or 120 degree scale and plus or minus 2 percent accuracy. Where indicated, provide transfer device with an off position.
  6. Current Sensors: Rated to suit application.
  7. Phase-Failure Relay: Provide relay for each motor 2 HP and larger. Relay shall have solid-state sensing circuit with isolated contacts for hard-wired connection to socket. Provide matching pin type relay and hold down clamps. Relay shall be arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 percent, or loss of supply voltage. Provide adjustable response delay, and adjustable under-voltage setting.

## PART 3 - EXECUTION

### 3.1 INSPECTION:

- A. Inspect area and conditions under which electrical connections for equipment are to be installed and notify Contractor in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

### 3.2 INSTALLATION OF ELECTRICAL CONNECTIONS:

- A. Furnish, set in place, and wire (except as may be otherwise indicated) all heating, ventilating, air conditioning, plumbing and fire protection, elevator, etc., motors and controls in accordance with the following schedule and in accordance with equipment manufacturer's written instructions and with recognized industry practices, and complying with applicable requirements of UL, NEC and NECA's "Standard of Installation" to ensure that products fulfill requirements. Carefully coordinate with work performed under the Mechanical Divisions of these Specifications.
- B. Coordinate with other work, including wires/cables, raceway and equipment installation, as necessary to properly interface installation of electrical connections for equipment with other work.
- C. Connect electrical power supply conductors to equipment conductors in accordance with equipment manufacturer's written instructions and wiring diagrams. Mate and match conductors of electrical connections for proper interface between electrical power supplies and installed equipment.
- D. Maintain existing electrical service and feeders to equipment serving occupied areas and operational facilities, unless otherwise indicated, or when authorized otherwise in writing by Owner, or Architect/Engineer. Provide temporary service during interruptions to existing facilities. When necessary, schedule momentary outages for replacing existing wiring systems with new wiring systems. When the "cutting over" has been successfully accomplished, remove, relocate, or abandon existing wiring as indicated.
- E. Cover splices with electrical insulating material equivalent to, or of greater insulation resistive rating, than electrical insulation rating of those conductors being spliced.
- F. Prepare cables and wires, by cutting and stripping covering armor, jacket, and insulation properly to ensure uniform and neat appearance where cables and wires are terminated. Exercise care to avoid cutting through tapes which will remain on conductors. Also avoid "ringing" copper conductors while skinning wire.
- G. Trim cables and wires as short as practicable and arrange routing to facilitate inspection, testing and maintenance.
- H. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturers published torque values for equipment connectors. Accomplish tightening by utilizing proper tools, including torque screwdriver, beam-type

torque wrench, and ratchet wrench with adjustable torque settings. Where manufacturer's torque requirements are not available, tighten connectors and terminals to comply with torque values contained in UL's 486A.

- I. Install pre-finished cord set where connection with attachment plug is indicated or specified, or use attachment plug with suitable strain-relief clamps.
- J. Provide suitable strain relief clamps for cord connection to outlet boxes and equipment connection boxes.
- K. Make wiring connections in control panel or in wiring compartment of pre-wired equipment in accordance with manufacturer's instructions. Provide interconnecting wiring where indicated.
- L. Install disconnect switches, controllers, control stations, and control devices such as limit switches and temperature switches as indicated or per manufacturer's instructions.
- M. Provide each motor with a horsepower rated disconnect switch and external thermal overload protection.
- N. Provide circuit and motor disconnect switches as indicated and where required by Code. Comply with switch manufacturers printed installation instructions. Install within sight of motors.

### 3.3 FIELD QUALITY CONTROL:

- A. Upon completion of installation of electrical connections, and after circuitry has been energized with rated power source, test connections to demonstrate capability and compliance with requirements. Ensure that direction of rotation of each motor fulfills requirement. Correct malfunctioning units at site, then retest to demonstrate compliance.

### 3.4 EQUIPMENT CONNECTION SCHEDULES:

#### A. Mechanical Equipment:

- 1. Refer to Mechanical Equipment Schedule on the drawings.
- 2. All load voltage wiring shall be provided under Division 26.
- 3. Unless otherwise indicated, it is suggested that all equipment motors and control shall be furnished, set in place, and wired in accordance with the schedule contained herein. The exact furnishing and installation of the equipment is left to the Contractors involved. Contractor should note that the intent of this schedule is to have the Contractor responsible for coordinating all wiring as outlined, whether or not specifically called for by the Divisions 20 through 28 drawings and specifications. Comply with the applicable requirements of Division 26 for all electrical work which is not otherwise specified. No

extras will be allowed for contractor's failure to provide for these required items. Contractor shall refer to the Division 26 and Divisions 20 through 28 specifications and plans for all power and control wiring and shall advise the Architect/Engineer of any discrepancies prior to bidding.

ITEM	FURNISHED BY	SET BY	CONTROL WIRING (non-load voltage)
1. Mechanical Equipment Motors	M	M	--
2. Special Equipment (i.e., elevators, etc.) a. Motors b. Magnetic Motor Starters c. Disconnect Switches Thermal OL Switches Manual Operating Switches	G G E	G E* E	-- -- --
3. Motor Starters, combination motor starter/disconnect and Variable Frequency Drives a. Automatically controlled, with or without HOA switches. b. Manually controlled. c. Starters integral with motor control centers including control relays and transformers. d. Combination Starter/Disconnects	M M E M	E* E* E E*	M -- -- M
4. Pushbutton stations, pilot lights	M	E*	M
5. Disconnect switches, thermal overload switches, manual operating switches.	E	E*	M
6. Multi-speed switches	M	E*	M
7. Control relays, transformers.	M	M	M

8. Load voltage control items such as line voltage thermostats not connected to control panel systems.	M	M	E
9. Non-load voltage control items.	M	M	M
10. Electric thermostats, remote bulb thermostats, motor valves, float controls, etc., which are an integral part of mechanical equipment or directly attached to ducts, pipes, etc.	M	M	M
11. Motor valves, damper motor, solenoid valves, EP and PE switches, VAV box controls, actuators, etc.	M	M	M**
12. Control circuit outlets	E	E	--
13. Fire protection controls (Including flow switches)	M	M	M**
14. Duct smoke detectors, including relays for fan shutdown.	E	M	M**
15. Temperature Control Panel	M	M	M
16. Interlocks	M	M	M

G = General, Division 13 or 14

M = Mechanical, Divisions 20 through 25

E = Electrical, Division 26

\* For factory pre-wired equipment specified under other Divisions, all wiring within the equipment shall be by the manufacturer. Connection to the equipment shall be by Division 26, as shown on electrical drawings.

Manufacturer's equipment provided under other divisions which varies from what is shown on Division 26 drawings shall be the responsibility of the Contractor to complete and pay for any costs for those variations.

\*\* Fire alarm system control modules and wiring from fire alarm contacts to fire alarm system under Division 28. See details.

\*\*\* Integral control wiring under Electrical Division as manufacturer supplied equipment. Control wiring for automatic control portion under Mechanical Divisions.

4. Owner Furnished Equipment:

- a. Refer to Owner Equipment Schedule on drawings.
- b. Refer to System Coordination Schedule on drawings.



5. Kitchen Equipment:
  - a. Refer to equipment plan, elevation drawings, and equipment Schedules.

**END OF SECTION 26 05 53**

**SECTION 26 22 00 - TRANSFORMERS**

**PART 1 - GENERAL**

**1.1 SUMMARY:**

- A. This section includes general purpose and specialty dry type transformers and voltage regulators with windings rated 600 V or less.

**1.2 SUBMITTALS:**

- A. Product Data: Submit manufacturer's technical product data including rated kVA, frequency, primary and secondary voltages, percent taps, polarity, impedance and certification of transformer performance efficiency at indicated loads, percentage regulation at 100% and 80% power factor, no-load and full-load losses in watts, % impedance at 75 deg. C, hot-spot and average temperature rise above 40 deg. C ambient temperature, sound level in decibels, and standard published data.
- B. Wiring diagrams from manufacturer differentiating between manufacturer-installed and field-installed wiring.
- C. Product certificates, signed by manufacturer of transformers certifying that their products comply with the specified requirements.

**1.3 QUALITY ASSURANCE:**

- A. Manufacturers: Firms regularly engaged in manufacture of transformers of types and ratings required for this project, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Installer's Qualifications: Firm with at least 5 years of successful installation experience on projects utilizing electrical power and distribution transformers similar to those required for this project.

**PART 2 - PRODUCTS**

**2.1 MANUFACTURERS:**

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
  - 1. Westinghouse
  - 2. General Electric Co.
  - 3. Square D Co.

- 4. ITE Siemens Energy & Automation, Inc.
- 5. Eaton
- 6. Hevi-Duty Electric.

**2.2 TRANSFORMERS, GENERAL:**

- A. Transformers: Factory assembled and tested, air cooled units of types specified, having characteristics and ratings as indicated. Units shall be designed for 60-Hz service.
- B. Cores: Grain oriented, non-aging silicon steel.
- C. Coils: Continuous windings without splices except for taps.
- D. Internal Coil Connections: Brazed or pressure type.

**2.3 GENERAL PURPOSE, DRY-TYPE TRANSFORMERS:**

- A. Comply with NEMA Standard ST 20 "Dry-Type Transformers for General Applications."
- B. Transformers shall have the following features and ratings:

- 1. Enclosure: Indoor, ventilated.

Enclosure: Indoor, ventilated, drip proof.

Enclosure: Outdoor, ventilated, raintight NEMA 3R.

Enclosure: Totally enclosed, nonventilated.

Enclosure: Totally enclosed, nonventilated, suitable for outdoor use.

- 2. Insulation Class: 185 deg C or 220 deg C class for transformers 15 kVA or smaller; 220 deg C class for transformers larger than 15 kVA.

- 3. Insulation Temperature Rise: 115 deg C maximum rise above 40 deg C.

- 4. Windings:

- a. 2-winding type, three phase transformers shall use one coil per phase in primary and secondary. Conductors shall be individually insulated, as small in size as possible, and transposed when necessary to minimize eddy current losses. The primary winding shall be of sufficient size to limit temperature rise to its rated value even with circulating 3rd harmonic current.

- b. Provide aluminum windings.

- c. Windings shall be delta-wye with 30° lagging phase shift to match ANSI standard, unless noted otherwise.
  5. Sound Level: Minimum of 3 dB less than NEMA ST 20 standard sound levels for transformer type and size indicated when factory tested in accordance with that standard.
  6. Taps: For transformers 3 kVA and larger, full capacity taps in high-voltage winding as follows:
    - a. kVA through and including 15 kVA: Two 5 percent taps below rated high voltage.
    - b. Greater than 15 kVA through and including 500 kVA: Six 2-1/2 percent taps, 2 above and 4 below rated high-voltage.
    - c. 750-1000 kVA: Four 2-1/2 percent taps, 2 above and 2 below rated high-voltage.
  7. BIL: 10kV for all windings.
  8. Secondary Neutral: Twice the ampacity of the secondary phase conductors.
  9. Core Flux Density: Maintained below saturation point to prevent core saturation caused by harmonics even with a 10% primary over-voltage.
- C. Accessories: The following accessory items are required where indicated:
1. Surge Arresters: Low voltage type, factory-installed and connected to high-voltage terminal; complying with NEMA Standard LA 1.
  2. Surge Arresters: Low-voltage type, factory-installed and connected to low-voltage terminals; complying with NEMA Standard LA 1.
  3. Electrostatic shielding (where indicated): Insulated metallic shield between primary and secondary windings. Connect to terminal marked "shield" for grounding connection.
  4. Wall mounting brackets: Manufacturers standard brackets for transformers sized up to 75 kVA where wall mounting is indicated.
  5. Fungus Proofing: Permanent fungicidal treatment for coil core.

#### 2.4 BUCK-BOOST TRANSFORMERS:

- A. Comply with NEMA Standard ST 1 "Specialty Transformers", and UL Standard 506, "Specialty Transformers."
- B. Ratings: As indicated, and for continuous duty.

- C. Type: Self-cooled, dry type, connected as autotransformers to provide the percentage of buck or boost indicated.
- D. Enclosure: Suitable for the location indicated.
- E. Sound Level: Minimum of 3 dB less than NEMA Standard ST 1 for transformer of type and size indicated when factory tested in accordance with that standard.

#### 2.5 CONTROL AND SIGNAL TRANSFORMERS:

- A. Comply with NEMA Standard ST 1 "Specialty Transformers", and UL Standard 506, "Specialty Transformers."
- B. Ratings: As indicated and for continuous duty. Where rating is not indicated, provide capacity in excess of load.
- C. Type: Self-cooled, two-winding dry type.
- D. Enclosure: Indoor, except as indicated.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION:

- A. Arrange equipment to provide adequate spacing for cooling air circulation.
- B. Identify transformers in accordance with Section 26 05 53 on Electrical Identification.
- C. Tighten electrical connectors and terminals in accordance with manufacturer's published torque values. Where manufacturer's torque values are not indicated, use those specified in UL 486A for copper and UL 486B for aluminum.
- D. Install transformers as indicated, complying with manufacturer's written instructions, applicable requirements of NEC, NESC, NEMA, ANSI and IEEE standards, and in accordance with recognized industry practices to ensure that products fulfill requirements.
- E. Install units on vibration mounts; comply with manufacturer's indicated installation method, if any. Vibration mounts shall be Neoprene seismic isolator series RSM as manufactured by Vibration Mountings and Controls/Aeroflex.
- F. Where indicated, suspend transformer from structure using transformer mounting detail as shown on the drawings.
- G. Only totally enclosed non-ventilated transformers are allowed to be installed in ceiling air plenum spaces.

**3.2 GROUNDING:**

- A. Ground transformers and tighten connections to comply with torque values specified in UL Standard 486A.

**3.3 FIELD QUALITY CONTROL:**

- A. Tests shall conform to National Electrical Testing Association (NETA) Standard ATS, "Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems," and the following:
  - 1. Test Objectives: To assure transformer installation is operational within industry and manufacturer's tolerances, is installed in accordance with Contract Documents, and is suitable for energizing.
  - 2. Procedures: Upon satisfactory completion of tests, attach a label to tested components.
  - 3. Schedule tests and notify Engineer/Architect at least one week in advance of schedule and of test commencement.
  - 4. Reports: Provide a written report of observations and tests. Report defective materials and workmanship and retest corrected defective items.
  - 5. Submit written test reports to the Architect/Engineer.
  - 6. Testing for transformers shall include verification of manual and/or automatic switching, protection, or control devices, insulation resistance test, taps verification, excitation test, and audible sound level tests.
  - 7. Provide tap voltage readings and adjust tap connections for appropriate secondary voltage. Include tap settings and voltage readings in test report.

**3.4 ADJUSTING AND CLEANING:**

- A. Upon completion of installation, inspect interiors and exteriors of accessible components. Remove paint splatters and other spots, dirt, and construction debris. Touch up scratches and mars of finish to match original finish.
- B. Adjust transformer taps to provide optimum voltage conditions at utilization equipment.

**3.5 PROTECTION:**

- A. Temporary Heating: Apply temporary heat in accordance with manufacturer's recommendations within enclosure of each transformer throughout periods during

which equipment is not in a space that is continuously under normal control of temperature and humidity.

**END OF SECTION 26 22 00**

**SECTION 26 24 13 - SWITCHBOARDS****PART 1 - GENERAL****1.1 SUMMARY:**

- A. This Section includes low-voltage power service and distribution switchboards and associated auxiliary equipment rated 600 V or less.

**1.2 SUBMITTALS:**

- A. Product data for each product and component specified.
- B. Shop drawings for each switchboard including dimensioned plans and elevations, component and device lists, and a single-line diagram showing main and branch bus current ratings and continuous and short-circuit ratings of switchboard.
- C. Shop drawings or other descriptive documentation of optional barriers specified for electrical insulation and isolation. Show front and side views of enclosures with dimensions.
- D. Shop drawings of utility company metering provisions with indication of approval by utility company.
- E. Schedule of features, characteristics, ratings, and factory settings of individual protective devices.
- F. Manufacturer's Schematic Wiring Diagram.
- G. Point-to-Point Control Wiring Diagram: Differentiating between manufacturer-installed and field- installed wiring (may be submitted upon delivery of switchboard).

**1.3 QUALITY ASSURANCE:**

- A. Listing and Labeling: Provide switchboard assemblies that are listed and labeled.
  - 1. The terms "listed" and "labeled": As defined in the National Electrical Code, Article 100.
- B. Product Selection for Restricted Space: The Drawings indicate maximum dimensions for switchboard equipment including clearances between switchboard and adjacent surfaces and items. Switchboards having equal performance characteristics and complying with indicated maximum dimensions may be considered.
- C. Manufacturer's Qualifications: Firms regularly engaged in the manufacture of switchboards, of types, sizes and capacities required, and whose products have been in satisfactory use in similar service for not less than 5 years.



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

#### 1.4 DELIVERY, STORAGE, AND HANDLING:

- A. Deliver switchboards and components properly packaged and mounted on pallets, or skids to facilitate handling of heavy items. Utilize factory-fabricated handling of heavy items. Utilize factory-fabricated type containers or wrapping for switchboards and components which protect equipment from damage. Inspect equipment to ensure that no damage has occurred during shipment.
- B. Deliver in shipping splits of lengths that can be moved past obstructions in delivery path as indicated.
- C. Store switchboard equipment in original packaging and protect from weather and construction traffic. Wherever possible, store indoors; where necessary to store outdoors, store above grade and enclose with watertight wrapping. Store so condensation will not occur on or in switchboards. Provide temporary heaters as required to assure avoiding condensation.
- D. Handle switchboard equipment carefully to prevent physical damage to equipment and components. Remove packaging, including the opening of crates and containers, avoiding the use of excessive hammering and jarring which would damage the electrical equipment contained therein. Do not install damaged equipment; remove from site and replace damaged equipment with new.

#### 1.5 EXTRA MATERIALS:

- A. Spare Fuses: Furnish spares of each type and rating of fuse for fusible devices amounting to one set of 3 fuses for each 9 fuses installed but not less than 3 fuses of each type. Include spares for:
  - 1. Fuses for fused circuit breakers.
  - 2. Fuses for fusible switches.
  - 3. Fuses for fused power circuit devices.
  - 4. Control power fuses.
  - 5. Potential transformer fuses.
- B. Spare Indicating Lamps: Furnish 6 of each type and color installed.
- C. Touch-Up Paint: Furnish 3 half-pint containers.

**1.6 SEQUENCING AND SCHEDULING:**

- A. Schedule delivery of switchboard equipment which permits ready building ingress for large equipment components to their designated installation spaces. Coordinate delivery of equipment with the installation of other building components.
- B. Coordinate size and location of concrete equipment pads. Cast anchor bolt inserts into pad.
- C. Coordinate with other electrical work including raceways, electrical boxes and fittings, and cabling/wiring, as necessary to interface installation of switchboards.

**PART 2 - PRODUCTS****2.1 MANUFACTURERS:**

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
  - 1. General Electric Co.
  - 2. Siemens Energy & Automation, Inc.
  - 3. Square D Co.
  - 4. Westinghouse
  - 5. Eaton
  - 6. Cutler-Hammer, Inc.
  
- B. Metering Equipment:
  - 1. General Electric
  - 2. Siemens Energy & Automation, Inc.
  - 3. Square D Co.
  - 4. Westinghouse
  - 5. Eaton
  - 6. ABB Power Distribution, Inc.
  - 7. Sangamo

**8. TESCO****2.2 SWITCHBOARDS, GENERAL:**

- A. Description: Front-connected, front-accessible with fixed, individually mounted main device, panel-mounted branches, and sections rear aligned. Dead front, metal enclosed, self-supporting and conforming to NEMA PB2.
- B. Barriers: Between adjacent switchboard sections.

**2.3 FABRICATION AND FEATURES:**

- A. Enclosure: Steel. NEMA 1.
- B. Enclosure Finish for Indoor Units: Manufacture standard gray finish over a rust inhibiting primer on phosphatizing treated metal surface. Provide painted surfaces that conform to IEEE C37.20.1, "Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear."
- C. Utility Metering Compartment: Fabricated compartment and section meeting utility company requirements. Where separate, vertical section is required for utility metering, match and align with basic switchboard.
  - 1. Provide integral meter base in accordance with utility standards.
- D. Bus Transition and Incoming Line Pull Sections: Where required, match and align with basic switchboard. Line terminations shall be accessible from the front of the switchboard.
- E. Hinged Front Panels: Provide to allow access to breaker, metering, accessory, and blank compartments.
- F. Pull Box on Top of Switchboard: Provide where indicated or where required by installation conditions, and include the following features:
  - 1. Adequate ventilation to maintain air temperature in pull box within same limits as switchboard.
- G. Buses and Connections: Three-phase, four-wire except as otherwise indicated. Features as follows:
  - 1. Phase and Neutral Bus Material: Hard-drawn copper, 98 percent conductivity with feeder circuit-breaker line connections. Horizontal cross busses throughout shall be non-tapered – 100 percent rated. Size bus in accordance with NEMA PB2.
  - 2. Contact Surfaces of Buses: Silver plated copper.

3. Main Phase Buses, Neutral Bus, and Equipment Ground Bus: Uniform capacity the entire length of the switchboard main and distribution sections. Provide for future extensions from either end by means of bolt holes or other approved method and connecting links. Provide for any outgoing or incoming bus or cabling as required for each breaker space (i.e. all spares, spaces, and utilized).
  4. Neutral Buses: 100 percent ampacity of the phase buses except as indicated and equipped with approved pressure connector terminations for outgoing circuit neutral cables.
  5. Provide two bolt copper compression lugs for all incoming and outgoing feeders including neutral and ground connections.
- H. Ground Bus: 1/4 inch by 2 inch minimum size, hard-drawn copper of 98 percent conductivity, and equipped with pressure connector terminations for feeder and branch-circuit ground conductors.
- I. Supports and Bracing for Buses: Adequate strength for indicated short-circuit currents. Busses shall be bolted with access for future torque maintenance.
- J. Provide four (4) spare two-hole lugs for #2 AWG through #4/0 AWG conductors on load side of main circuit breakers.
- K. Provide lugs on load side of distribution device (breakers, switches, etc.), including neutral and ground lugs, as shown on the drawings and as necessary to meet or exceed capacity of OCPD.
- L. Provide internal bussing to output lugs or bus flange for each spare breaker provided. All spare cells shall be wired complete to match other cells being utilized. Provide output lugs or bus flange for each spare. Provide lugs unless flange is specifically noted.
- 2.4 OVERCURRENT PROTECTIVE DEVICES (OCPDS):
- A. Comply with requirements of Section 26 28 00 on Overcurrent Protective Devices for types of OCPDs indicated. Provide indicated features, ratings, characteristics, and settings.
  - B. Future Devices: Where provision for future overcurrent protective devices or space is indicated, equip compartments with mounting brackets, supports, bus connections, and necessary appurtenances, designed for the OCPD types and ampere ratings indicated for future installation of devices.
- 2.5 OTHER CIRCUIT CONTROL AND PROTECTIVE DEVICES:
- A. General: Factory-installed and tested devices of types listed below, with indicated ratings, settings, and features.

- B. Control Power: Where electrically operated/shunt-tripped circuit breakers or other control power functions are required, provide 120 volt control circuits supplied through secondary disconnect devices from a control power transformer. Include the following features:
1. Control Power Transformers: Dry type. Separate compartments for units larger than 3 KVA and their fuses.
  2. Provide two control power transformers in separate compartments with necessary interlocking relays. Connect the primary of each control power transformer at the line side of the associated main circuit breaker. Connect the 120 volt secondary through a relay or relays as a control bus.
  3. Control Power Fuses: Include primary and secondary fuses for current-limiting and overload protection.
  4. Provide control power disconnecting means on line side of transformer.
  5. Provide control fuse status indication on front and contacts for remote alarm.
- C. Control Wiring: Factory installed, complete with bundling, lacing, and protection, and complying with the following:
1. Flexible Conductors: Use for size No. 8 and smaller and for conductors across hinges, and conductors for interconnections between shipping units.
  2. Conductors Sizes: In accordance with NEC for the duty required.
  3. All control wiring shall be terminated on labeled power type terminal blocks with ring terminals.
  4. Limit cable bundles to 12 cables maximum.
- D. Ground Fault Interlock: Provide ground fault relays and interlocks as follows:
1. The ground fault relays on the main breakers shall be zone interlocked with the ground fault relays on all associated branch breakers in the main distribution sections.
  2. The ground fault relays on the branch breakers in the main distribution center (for single ended, double ended, or that serve a common transfer breaker bay) shall be set as a summation scheme to provide ground fault protection. For multi-fed switchboards where the neutral has multiple grounds, provide residual connection of ground fault CT's with a set of CT's on the common output of the transfer breakers.

3. Provide CT's as required for all breaker cells provided. Provide all interconnecting wiring and terminal blocks as required.
  4. Provide ground fault protection of the generator feeders and the generator mains and bus duct to the main distribution centers utilizing differential relays.
  5. Provide ground fault relays for each breaker cell provided. Provide all interconnecting wiring and terminal blocks as required.
- E. Surge Arresters (UL SA rated-category OWXH): Provide distribution class, metal oxide Varistor as specified in IEEE C62.11, "Standards for Metal-Oxide Surge Arresters for AC Power Circuits," or IEEE C62.1 "Gapped Silicon-Carbide Surge Arresters for Alternating Current Power Circuits." Install in the service entrance cable termination compartment and connect in each phase of each incoming circuit. Coordinate rating with circuit voltage.
1. Description: Coordinate impulse spark-over voltage with system circuit voltage, and provide factory mounting and connection.
- F. TVSS: Provide transient voltage surge suppression for switchboard. Refer to Section 26 43 13 "Transient Voltage Surge Suppression" for requirements.

## 2.6 INSTRUMENTATION:

- A. Provide the items specified below and mount within utility metering compartment or on front cover of associated breaker.
1. Instrument Transformers: NEMA Standard EI 21.1, "Instrument Transformers for Revenue Metering 110 kV BIL and Less," IEEE Standard C57.13, "Requirements for Instrument Transformers," and the following:
    - a. Potential Transformers: Secondary voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
    - b. Current Transformers: Ratios and accuracy class suitable for connected relays, meters, and instruments.
  2. Electronic Circuit Monitor: Provide multi-function digital instrumentation mounted on switchboard for main bus and for each branch breaker connection which contains the following functions:
    - a. REAL TIME Readings:
      - 1) Current (Per Phase, N, G, 3X)
      - 2) Voltage (L-L, L-N)
      - 3) Real Power (Per Phase, 3-phase)

- 4) Reactive Power (Per Phase, 3-phase)
  - 5) Apparent Power (Per Phase, 3-phase)
  - 6) Power Factor (Per Phase, 3-phase)
  - 7) Frequency
  - 8) THD (Current and Voltage)
  - b. Demand Readings (Maximum power demand over a 15 minute period continuously recorded over a minimum 30 day period per NEC):
    - 1) Demand-Current (Per Phase Present, Peak)
    - 2) Demand-Real Power (3-phase total) (KWD)
    - 3) Demand-Reactive Power (3-phase Total) (KVARD)
    - 4) Demand Apparent Power (3-phase Total) (KVAD)
  - c. Energy Readings:
    - 1) Real energy
    - 2) Reactive Energy
    - 3) Apparent Energy
    - 4) Energy Accumulation (Signed, Absolute, Energy-In and Energy-Out)
    - 5) KYZ Output.
  - d. The circuit monitor shall be capable of interfacing with a personal computer and other monitors. Provide all interface software and a communication port cable.
  - e. UL 508 listed.
3. Watt-Hour Meter: Flush or semi-flush type, rated 5 amps, 120 V, 3 phase, 3 wire, with 3 elements, 15-minute-indicating-demand register and provision for testing and adding pulse initiation.

**2.7 RATINGS:**

- A. Provide nominal system voltage, continuous main bus amperage, and short-circuit-current ratings as indicated on the drawings.

**2.8 ACCESSORY COMPONENTS AND FEATURES:**

- A. Spare Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented, steel box or cabinet. Arrange for wall mounting.

#### 2.9 IDENTIFICATION:

- A. General: Refer to Section 26 05 53 on Electrical Identification. Identify units, devices, controls, and wiring with factory-applied labels and signs.
- B. Compartment Nameplates: Engraved laminated plastic or metal nameplate for each compartment, mounted with corrosion-resistant screws.
- C. UL nameplates shall be provided for all switchboards. Information shall include, but not be limited to, manufacturer, model number, serial number, plant or manufacturing location, ampere rating, voltage rating, wire and phase identification and bus short circuit bracing rating.

### PART 3 - PRODUCTS

#### 3.1 INSTALLATION:

- A. General: Install switchboards and accessory items in accordance with manufacturers' written installation instructions and the following specifications:
- B. Anchor each switchboard assembly to the leveled concrete base in accordance with manufacturer's recommendations. Attach by bolting using minimum of 3/8 inch bolts. Meet appropriate seismic zone requirements.
- 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 printed, basic operating instructions. Include building main one line diagram for switchboards, including control and emergency procedures (when applicable). Include building main one-line diagram. Fabricate frame and cover with clear acrylic plastic. Frame shall be open at the top for easy removal of drawings for use and updating. Mount on the front of the switchboards.

#### 3.2 IDENTIFICATION:

- A. Identify field-installed wiring and components, and provide warning signs as specified in Section 26 05 53 "Electrical Identification".

#### 3.3 GROUNDING:



- A. Connections: As indicated. Tighten connections to comply with torque values specified in UL 486A and 486B.

### 3.4 CONNECTIONS:

- A. Tighten switchboard bus joint bolts and electrical connector and terminal bolts in accordance with manufacturer's published torque values. Where manufacturer's torque values are not stated, use those specified in UL 486A for copper and UL 486B for aluminum.

### 3.5 FIELD QUALITY CONTROL:

- A. General: Comply with applicable standards of the National Electrical Testing Association (NETA) including Standard ATS, "Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems."

- B. Manufacturers Field Testing and Start-Up: Manufacturer shall have NETA certified technician perform the following quality control testing, visual and mechanical inspections, electrical tests, and tests of the LV power switchgear.

1. Pretesting: Upon completing installation of the system, perform manufacturer's recommended testing, NETA testing, and the following preparations for tests:

- a. Make insulation resistance tests of connecting supply, feeder and control circuits.
- b. Make continuity tests of circuits.
- c. Provide set of Record Documents. Include full updating on final system configuration and parameters where they supplement or differ from those indicated in original Contract Documents.
- d. Provide manufacturer's instructions for installation and testing of switchgear assembly to Owner and Engineer.
- e. Visual inspection of all factory and field wiring for proper live bus clearance and secured for fault currents.

2. Quality Control Testing Program: Conform to the following:

- a. Test Objectives: To assure switchgear installation meets specified requirements, is operational within specified tolerances, provides appropriate protection for system and equipment, and is suitable for energizing.
- b. Procedures: Make field tests and inspections and prepare switchgear assemblies for satisfactory operation in accordance with NETA Standard ATS ("Acceptance Testing Specifications for Electrical Power, Distribution Equipment and Systems")

applicable IEEE standards, manufacturer's recommendations, and these specifications.

- c. Schedule tests and provide notification at least one week in advance of test commencement.
- d. Reports: Prepare written reports of test results and observations. Report defective materials and workmanship. Include complete records of repairs and adjustments.
- e. Labeling: Upon satisfactory completion of tests and related effort, apply a label to tested components indicated test results, date, and responsible person and organization.
- f. Visual and Mechanical Inspection: Include the following inspections and related work:
  - 1) Inspect, for defects and physical damage, testing laboratory labels and nameplate compliance with current single-line diagrams. Verify smooth and proper operation of all doors, hinges, handles, latches, etc. Correct or replace as determined necessary by the Owner/Engineer.
  - 2) Verify that current transformers, potential transformers, and fuses meet specified requirements. Verify relays, meters, and instrumentation are checked and all connections are made properly. Introduce accurately metered currents and/or voltages to relays and other devices which will enable accurate determination of the tripping or activation characteristics.
  - 3) Perform mechanical operational tests in accordance with manufacturer's instruction manual. Manually exercise each operating mechanism, switches, circuit breakers, etc.
  - 4) Check switchgear anchorage, area clearances, and alignment and fit of drawout components in compartments. Verify switchgear, switchgear supports and attachments are designed and installed for appropriate seismic zone.
  - 5) Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.
  - 6) Clean switchgear assembly using manufacturer's approved methods and materials.
- g. Electrical Tests: Include the following items performed in accordance with manufacturer's instruction:
  - 1) Insulation resistance test of buses and portions of control wiring that disconnect from solid-state devices through normal disconnecting features. Insulation resistance less than 100 megohms is not acceptable. Tests shall be made phase to

phase, phase to neutral, and phase to ground with switches in the open and closed positions.

- 2) Ratio and polarity tests on current and voltage transformers, not integral with overcurrent protective devices.
  - 3) Ground resistance test on system and equipment ground connections.
  - 4) Calibration of ammeters and voltmeters at midscale.
  - 5) Verify appropriate capacity, overcurrent protection, and operating voltage of control power elements including control power transformer and control power wiring.
  - 6) Calibrate watt-hour and demand meters to 0.5 percent, and verify meter multipliers.
  - 7) Provide operational test of each automatic breaker, alarm and indication. Provide manual tests initially and proceed to full automatic testing that tests each manual and automatic function, sequence and scenario. Verify and document each sequence including operation of interlocks, relays, etc.
  - 8) Tests of Overcurrent Protective Devices: Testing of overcurrent protective devices shall be conducted according to procedures outlined in overcurrent protective devices specification section.
  - 9) Provide complete individual and system testing of ground fault devices and system.
- h. Retesting: Correct deficiencies identified by tests and observations and retest switchboards. Verify by the retests that switchboards meet specified requirements.

### 3.6 CLEANING:

- A. Upon completion of installation, inspect interior and exterior of switchboards. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

### 3.7 PROTECTION:

- A. Temporary Heating: Apply temporary heat in accordance with manufacturer's recommendation within each section of switchboards throughout periods during which the switchboard is not in a space that is continuously under normal control of temperature and humidity.

### 3.8 DEMONSTRATION:

- A. Training: Arrange and pay for the services of factory-authorized service representatives to demonstrate and test switchboards and train Owner's maintenance personnel. Conduct a minimum of one day of training in operation and maintenance as required under the LPS General Conditions of the Contract on Project Closeout. Include both classroom training and hands-on equipment operation and maintenance procedures. Record training video on VCR tape or Recordable DVD and turn video over to Owner with O&M Manuals.
- B. Schedule training with at least seven (7) days advance notification.

**END OF SECTION 26 24 13**

**SECTION 26 24 16 - PANELBOARDS****PART 1 - GENERAL****1.1 SUMMARY:**

- A. This Section includes lighting and power panelboards and associated auxiliary equipment rated 600 V or less.

**1.2 DEFINITIONS:**

- A. Overcurrent Protective Device (OCPD): A device operative on excessive current that causes and maintains the interruption of power in the circuit it protects.

**1.3 SUBMITTALS:**

- A. Product data for each type panelboard, accessory item, and component specified.
- B. Shop drawings from manufacturers of panelboards including dimensioned plans, sections and elevations. Show tabulations of installed devices, major features and voltage rating. Include the following:
  - 1. Enclosure type with details for types other than NEMA Type 1.
  - 2. Bus configuration and current ratings.
  - 3. Short-circuit current rating of panelboard.
  - 4. Features, characteristics, ratings, and factory settings of individual protective devices and auxiliary components.
- C. Wiring diagrams detailing schematic diagram including control wiring, and differentiating between manufacturer-installed and field-installed wiring.
- D. Report of field tests and observations.
- E. Panel schedules for installation in panelboards. Submit final versions after load balancing.

**1.4 QUALITY ASSURANCE:**

- A. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

1. The terms "listed" and "labeled" shall be defined as they are in the National Electrical Code, Article 100.
  - B. **Manufacturer's Qualifications:** Firms regularly engaged in manufacture of panelboards and enclosures, of types, sizes and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years.
  - C. **Installer's Qualifications:** A firm with at least 3 years of successful installation experience on projects utilizing panelboards similar to those required for this project.
- 1.5 **EXTRA MATERIALS:**
- A. **Keys:** Furnish six spares of each type for panelboard cabinet locks.
  - B. **Touch-up Paint for panelboards:** One half-pint container.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS:**

- A. **Manufacturers:** Subject to compliance with requirements, provide products by the following:
  1. General Electric Co.
  2. Westinghouse
  3. Siemens Energy & Automation, Inc.
  4. Square D Co.
  5. Eaton
  6. Cutler-Hammer, Inc.

### **2.2 PANELBOARDS, GENERAL REQUIREMENTS:**

- A. **Overcurrent Protective Devices (OCPDs):** Provide type, rating, and features as indicated. Comply with Section 26 28 00 on Overcurrent Protective Devices, with OCPDs adapted to panelboard installation. Tandem circuit breakers shall not be used. Multiple breakers shall have common trip.
- B. **Enclosures:** Cabinets, flush or surface mounted as indicated. NEMA Type 1 enclosure, except where the following enclosure requirements are indicated. Provide galvanized sheet steel cabinet type enclosures, in sizes and NEMA types as indicated, code-gauge, minimum 16-gauge thickness. Construct with multiple knockouts and wiring gutters. Provide baked gray enamel finish over a rust inhibitor coating. Design enclosures for recessed mounting.

Provide enclosures which are fabricated by same manufacturer as panelboards, which mate and match properly with panelboards to be enclosed.

1. NEMA 3R: Raintight
  2. NEMA 3S: Raintight and dust tight.
  3. NEMA 4X: Corrosion-resistant fiberglass enclosure, watertight, dust tight, and resistant to oil and coolant seepage.
  4. NEMA 12: Dust tight, drip proof, and resistant to oil and coolant seepage.
- C. Front: Hinged trim type, secured to box with 1/4-20-large head slotted captive screws except as indicated. Front for surface-mounted panels shall be same dimensions as box. Fronts for flush panels shall overlap box except as otherwise specified. Provide fronts with hinged trim construction and door with flush locks and keys, all panelboard enclosures keyed alike, with concealed door hinges on inner door, piano hinge on outer trim door, and door swings as indicated.
- D. Directory Frame: Metal, mounted inside each panel door with card and clear plastic cover. Directory shall match panelboard configuration, i.e. top to bottom, left to right. Provide permanent panelboard labels for each circuit number.
- E. Bus Material: Provide tin plated hard-drawn copper of 98 percent conductivity.
- F. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors, and bonded to box.
- G. Provide copper lugs for incoming feeders and grounds.
- H. Service Equipment Approval: Listed for use as service equipment for panelboards having main service disconnect.
- I. Provide minimum short circuit current ratings as indicated.
- J. Provision for Future Devices: Equip with mounting brackets, bus connections, and necessary appurtenances, for the OCPD ampere ratings indicated for future installation of devices.
- K. Special Features: Provide the following features for panelboards as indicated.
1. Isolated Equipment Ground Bus: Adequate for branch-circuit equipment ground conductors; insulated from box to be supplied where indicated.

2. Split Bus: Vertical bus of indicated panels divided into two vertical sections with connections as indicated.
  3. Skirt For Surface-Mounted Panels: Same gauge and finish as panel front with flanges for attachment to panel, wall, and floor.
  4. Contactors in Mains: Mechanically held, with current rating, poles, and connections as indicated. Conform to Division 26 Section "Motor Controller," except omit overload protection.
  5. Control Power Source: Control power transformer of capacity indicated, for contactor shunt trip or other devices. Mount in cabinet of panel indicated. Protect primary with current-limiting OCPD as indicated. Provide fused protection of control circuits.
  6. Extra Gutter Space: Dimensions and arrangement as indicated or required.
  7. Gutter Barrier: Arranged to isolate section of gutter as indicated.
  8. Provide 150 percent sized neutral bus and ground bus and double termination lugs for all 120/208 volt panelboards.
  9. Column-Type Panelboard Configuration: Narrow cabinet extended as wireway to overhead junction box equipped with ground and neutral terminal buses.
  10. Auxiliary Gutter: Conform to UL 870, "Wireways, Auxiliary Gutters and Associated Fittings."
  11. Subfeed: OCPD or lug provision as indicated.
  12. Feed-Through Lugs: Sized to accommodate feeders indicated.
  13. Surge Arresters: IEEE C62.11, "Standards for Metal-Oxide Surge Arresters for AC Power Circuits," or IEEE C62.1, "Surge Arresters for Alternating Current Power Circuits."
    - a. Description: Coordinate impulse spark-over voltage with system circuit voltage and provide factory mounting with UL-recognized mounting device.
- 2.3 LIGHTING AND APPLIANCE BRANCH CIRCUIT PANELBOARDS:
- A. Branch OCPDs: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
  - B. Double-Width Panels: Where more than 42 poles are indicated, provide two panelboards of equal dimensions and with individual fronts on each panelboard. NEC now allows for more than 42-circuit panels (as designed).



**2.4 DISTRIBUTION PANELBOARDS:**

- A. Branch-Circuit Breakers: Where OCPDs are indicated to be circuit breakers, use bolt-on breakers except circuit breakers 225-ampere frame size and greater may be plug-in type where individual positive locking device requires mechanical release for removal.

**2.5 IDENTIFICATION:**

- A. General: Refer to Section 26 28 00 on Electrical Identification for labeling materials.
- B. UL nameplates shall be provided for all panelboards. Information shall include, but not be limited to, manufacturer, model number, serial number, plant or manufacturing location, ampere rating, voltage rating, wire and phase identification and bus short circuit bracing rating.

**PART 3 - EXECUTION****3.1 INSTALLATION:**

- A. General: Install panelboards and accessory items in accordance with NEMA PB 1.1, "General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less" and manufacturers' written installation instructions.
- B. Ground Fault Protection: Install panelboard ground fault circuit interrupter devices in accordance with installation guidelines of NEMA 289, "Application Guide for Ground Fault Circuit Interrupters."
- C. Mounting: Plumb and rigid without distortion of box. Mount flush panels uniformly flush with wall finish.
- D. Circuit Directory: Typed and reflective of final circuit changes required to balance panel loads. Obtain approval before installing.
- E. Install filler plates in unused spaces.
- F. Provision for Future Circuits at Flush Panelboards: Stub one 1 inch empty conduit from panel for each set of 3 spares or spaces into accessible ceiling space or space designated to be ceiling space in future. Stub one 1 inch empty conduits for each set of 3 spares or spaces into raised floor space or below slab other than slabs on grade.
- G. Auxiliary Gutter: Install where two panels are vertically mounted. Use gutter for branch circuit wiring to lower panel.
- H. Wiring in Panel Gutters: Train conductors neatly in groups, bundle, and wrap with wire ties after completion of load balancing.

**3.2 IDENTIFICATION:**

- A. Identify field-installed wiring and components and provide warning signs in accordance with Division 26 Section on electrical identification.

**3.3 GROUNDING:**

- A. Connections: Make equipment grounding connections for panelboards as indicated.
  
- B. Provide ground continuity to main electrical ground bus indicated.

**3.4 CONNECTIONS:**

- A. Tighten electrical connectors and terminals, including grounding connections, in accordance with manufacturer's published torque values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

**3.5 FIELD QUALITY CONTROL:**

- A. Upon completing installation of the system, perform the following tests:
  - 1. Make insulation resistance tests of panelboard buses, components, and connecting supply, feeder, and control circuits.
  - 2. Make continuity tests of circuits.
- B. Procedures: Make field tests and inspections and prepare panelboard for satisfactory operation in accordance with manufacturer's recommendations and these specifications.
- C. Schedule tests with at least one week of advance notification.
- D. Reports: Provide report written reports of tests and observations. Report defective materials and workmanship and unsatisfactory test results. Include records of repairs and adjustments made.
- E. Labeling: Upon satisfactory completion of tests and related effort, apply a label to tested components indicating results of tests and inspections, responsible organization and person, and date.
- F. Visual and Mechanical Inspection: Include the following inspections and related work:
  - 1. Inspect for defects and physical damage, labeling, and nameplate compliance with requirements of up-to-date drawings and panelboard schedules.

2. Exercise and perform of operational tests of all mechanical components and other operable devices in accordance with manufacturer's instruction manual.
  3. Check panelboard mounting, area clearances, and alignment and fit of components.
  4. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.
  5. Verify that proper grounding bushings/bonding/ and panel enclosure bonding is complete.
  6. Verify isolated neutral bar and neutral connections.
- G. Electrical tests: Include the following items performed in accordance with manufacturer's instruction:
1. Insulation resistance test of buses. Insulation resistance less than 100 meg-ohms is not acceptable.
  2. Ground resistance test on system and equipment ground connections.
  3. Test main and subfeed overcurrent protective devices in accordance with Section 26 28 00 "Overcurrent Protective Devices."
- H. Retest: Correct deficiencies identified by tests and observations and provide retesting of panelboards by testing organization. Verify by system tests that the total assembly meets specified requirements.
- 3.6 CLEANING:
- A. Upon completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and marks of finish to match original finish.

**END OF SECTION 26 24 16**

**SECTION 26 25 00 - BUSWAYS****PART 1 - GENERAL****1.1 SUMMARY:**

- A. This section includes plug-in and feeder busways, 600 V and under.

**1.2 SUBMITTALS:**

- A. Product Data: Submit manufacturer's data for busways, including sizes and types of enclosures, finishes, bus joints, bar configurations, temperature rise above ambient, and electrical ratings and characteristics.
- B. Coordination Drawings: Layout floor plans and elevations showing busway system. Designate components and accessories including clamps, brackets, hanger rods, bus plugs, tap boxes, expansion joints, straight lengths, fittings, firestops, and weather seals. Show accurately scaled components and spatial relationships to adjacent equipment and building features. Show busway types, dimensions, and finishes.

**1.3 QUALITY ASSURANCE:**

- A. Manufacturers: Firms regularly engaged in manufacture of busways, of types and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Installer's Qualifications: Firms with at least 3 years of successful installation experience on projects with electrical raceway work similar to that required for this project.

**1.4 DELIVERY, STORAGE, AND HANDLING:**

- A. Store busways in clean dry space having a uniform temperature and constant air circulation. If uniform temperature space is not available, provide temporary heat to keep storage space 10 deg F minimum above temperature of surrounding spaces.
- B. Handle busways to avoid damage to internal components, enclosures, and finishes. Avoid subjecting busway to twisting, denting, impact, and rough handling. Do not install damaged busway; remove from project site.
- C. Do not store busways outdoors. When unavoidable, provide temporary enclosures to protect against weather, moisture and debris. Install temporary electrical heating within enclosure to prevent condensation.

**1.5 EXTRA MATERIALS:**

A. Furnish the following extra materials matching products installed as described below, packaged with protective covering for storage and identified with labels clearly describing contents.

1. Bus Plugs: Furnish quantity of bus plug units equal to ten percent (10%) of amount installed, but no less than one unit of each type installed.
2. Provide spare plug-in devices as follows:

No. of Spares	AMP Rating	No. of Poles

**PART 2 - PRODUCTS**

**2.1 MANUFACTURERS:**

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. General Electric Co.
  2. Square D Co.
  3. Westinghouse Electric Corp.
  4. Siemens Energy & Automation, Inc.
  5. Eaton
  6. Cutler-Hammer Group; Eaton Corp.

**2.2 BUSWAYS, GENERAL:**

- A. Busway System: Indicated types, and complete with manufacturer's recommended fittings and accessories as indicated and as required for a complete, functioning installation.

- B. Busway features shall include conductor bus bars, electrical insulators, enclosures, flanges, elbows, offsets, cable tap boxes, expansion joints, end closures, supports, and other components and accessories needed to form complete systems.
- C. Ratings: Provide three-phase busway with voltage and current ratings and requirements for neutral and ground conductors as indicated. Short circuit ratings of busway shall be in excess of those indicated for each location.
- D. Conductor Material: Aluminum with not less than 55 percent conductivity.
- E. Provide an add/alternate to furnish conductor material of copper with not less than 98 percent conductivity.
- F. Bus Bars: Plated at electrical contact surfaces and insulated over entire length, except at contact surfaces, with 130 degrees C class insulation.
- G. Temperature Rise: Not in excess of 55 degrees C above an ambient temperature of 40 degrees C at any point in the busway when busway is operated at rated load current at 60 Hz.
- H. Overcurrent Protective Devices (OCPD's): Provide type, rating, and features as indicated. Comply with Section 26 28 00 Overcurrent Protective Devices, with OCPD's adapted to busway installation. Tandem circuit breakers shall not be used. Multiple breakers shall have common trip.

### 2.3 FEEDER BUSWAY:

- A. Construction: Totally enclosed, non-ventilated, and suitable for indoor installation except as otherwise indicated.
- B. Weatherproof Construction: Where indicated, totally enclosed, non-ventilated, and suitable for outdoor installation exposed to the weather. Provide galvanized steel enclosure and corrosion resistant hardware and fasteners.
- C. Conductor joints for one modular length to the next shall be arranged in joint stacks incorporating busway conductors, and each joint stack shall be arranged for tightening with a single bolt. Joint design shall be such that any length or fitting of a run may be removed without disturbing the connecting lengths.

### 2.4 PLUG-IN BUSWAY:

- A. Construction: Totally enclosed, non-ventilated and suitable for indoor installation.

- B. Conductor joints for one modular length to the next shall be arranged in joint stacks incorporating busway conductors, and each joint stack shall be arranged for tightening with a single bolt. Joint design shall be such that any length or fitting of a run may be removed without disturbing the connecting lengths.
- C. Plug-In Openings: Five, dead-front, hinged cover openings on each side of each 10 feet length of busway. Openings shall be useable simultaneously.

## 2.5 PLUG-IN DEVICES

- A. General: Compatible with the connected busway and of types as indicated. Plug-in devices shall be equipped with spring reinforced contact fingers arranged so they will not make contact with bus bars during plug insertion until the device housing is positively grounded to the busway. Plug-in devices shall lock in position mechanically and make positive grounding contact in addition to the power connection when in the fully inserted position. A safety interlock on bus plugs having "on" and "off" positions to prevent insertion when they are in the "on" position. Bus plugs for use with busway having an integral or internal ground bus shall be equipped with a grounding finger arranged to make positive contact with the ground bus before phase connections make contact when inserting the plug. Mounting hardware shall be captive on bus plug housing. Provide equipment engraved nameplate for each plug in device. Refer to section on Electrical Identification.
- B. Circuit Breaker Plugs: Capable of operation from the floor. Circuit breaker shall comply with NEMA AB 1, "Molded Case Circuit Breakers" with ratings and characteristics as indicated. Breaker shall have defeatable interlock with bus plug door.

## 2.6 FINISHES:

- A. Indoor Busway: Manufacturer's standard finish over corrosion resistant pretreatment.

## 2.7 SUPPORTS AND ACCESSORIES:

- A. General: As recommended by busway manufacturer and conforming to Section 26 05 29 "Supporting Devices".
- B. Spring Mounted Vertical Riser Supports: Adjustable for leveling and spring tension and arranged to permit relative movement between floor and busway.
- C. Expansion Section: Capacity and conductor provisions same as adjacent busway section. Arranged to absorb expansion and contraction of bus bars and housing.
- D. Bus shall be designed, constructed, and supported to meet applicable seismic zone requirements.

**2.8 FIRE STOPPING:**

- A. General: Materials UL listed and labeled and FM approved for fire ratings consistent with penetrated barriers.
- B. Wall and Floor Flanges: Sheet steel, 12-gauge minimum close fitting to busway and arranged to close the wall or floor opening at the busway penetration.
- C. Two-Part Sealant: Formed-in-place sealant.

**PART 3 - EXECUTION****3.1 INSTALLATION OF BUSWAYS:**

- A. Install busways and accessories as indicated and in compliance with applicable requirements of NEC and NEMA BU 1.1, "Instructions for Handling, Installation, Operation and Maintenance of Busway Rated 600 V or Less." Conform to manufacturer's written instructions except where more stringent requirements apply.
- B. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque values for equipment connectors. Where manufacturer's torque values are not indicated, tighten connectors and terminals to comply with torque values specified in UL Standards 486A and 486B.
- C. Expansion Fittings: Install at locations where busway crosses a building expansion joint. In addition, install at intervals in long runs or risers where length comes within ten percent (10%) of the maximum length without expansion joints stated by the manufacturer for the type and material of busway installed.
- D. Fire Stops: Install fire stops where busway penetrates fire-rated walls and floors. Seal between busway and opening and around opening with sealant or sealing mortar having NRTL listed fire rating not less than that of wall, or floor penetrated. Where busway manufacturer's sealing and stopping devices are not fire rated, provide fire stopping as required to satisfy authority having jurisdiction.
- E. Meet requirements of Section 26 28 00 on Overcurrent Protective Devices, for each bus plug furnished.
- F. Provide warning labels at all access openings and end sections.
- G. Floor Penetrations: Provide minimum 4 inch-high curb around busway within 12 inches of penetrations of floors to prevent water from spills and leaks from contacting busway.



- H. Support busway from the building structure independently from other suspended items at intervals not exceeding 5 feet unless otherwise designed and marked.
- I. Conform to manufacturer's recommendations for selection, spacing, and installation of supports.
- J. Strength of each support including fastenings to the structure shall be adequate to support busway load multiplied by a safety factor of at least four or 200 lb, whichever is greater.
- K. Fastening Supports: Unless otherwise indicated, fasten supports securely to the building structure as specified in Section 26 05 29 on Supporting Devices.

### 3.2 GROUNDING:

- A. Provide electrical bonding and equipment grounding connections for busways as indicated.
- B. Tighten bonding and grounding connections to comply with torque values specified in UL Standards 486A and 486B to assure permanent and effective grounding.

### 3.3 FIELD QUALITY CONTROL:

- A. Test busway runs prior to energizing as follows and provide written report of tests.
- B. Phasing: Verify that proper phase relationships exist between source, busway, and connected equipment using phase rotation meter and verifying phase continuity from source to equipment.
- C. Insulation Resistance: Measure for all busway components with 1000 Volt d.c. megohmmeter and compare in report with manufacturer's stated acceptable values. Measure each phase to phase and each phase to ground.
- D. Energize busway and demonstrate functioning in accordance with requirements.
- E. Test Failures: Correct deficiencies identified by tests and make ready for retest. Verify that equipment meets the specified requirements.
- F. Test each size of busway for voltage drop and report results. Indicate nominal voltage applied and voltage at output terminations for each phase to phase and phase to neutral connection.
- G. Compare test results as follows:  
  
One megohm per 100 feet of busway.

1. Provide 15 minute tests for each phase, neutral and ground bus with readings at 1 minute intervals.

**3.4 CLEANING AND FINISH REPAIR:**

- A. Upon completion of installation of busways, remove burrs, dirt, and construction debris and repair damaged finish including chips, scratches and abrasions.
- B. Galvanized Finish: Repair damage using a zinc-rich paint recommended by the manufacturer.
- C. Paint Finish: Repair damage using matching touch-up coating recommended by the manufacturer.

**3.5 ADJUSTMENT:**

- A. Align busway runs vertically and horizontally to eliminate sags and twists. Provide support stiffeners at locations where indicated and where there is excessive movement.
- B. Check bus plug circuit breaker trip settings, fuse ratings, and starter overload elements against connected loads and revise as required to conform to recommended values.

**END OF SECTION 26 25 00**

**SECTION 26 27 16 - ELECTRICAL CABINETS AND ENCLOSURES****PART 1 - GENERAL****1.1 SUMMARY:**

Work in this section is open to any product meeting the requirements of this Technical Guideline.

**1.2 QUALITY ASSURANCE:**

- A. In the absence of other information, the following standards apply:
  - 1. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum.)
  - 2. ANSI/NEMA ICS 1 – Industrial Control and Systems.
  - 3. ANSI/NEMA ICS 4 – Terminal Blocks for Industrial Control Equipment and Systems.
  - 4. ANSI/NEMA ICS 6 – Enclosures for Industrial Control Equipment and Systems.
- B. Coordination: See Fire Alarm and Mass Notification (FA MN) Standards Diagrams.

**1.3 SUBMITTALS:**

- A. Product Data: Required for all installation materials.
- B. Shop Drawings:
  - 1. Cabinets:
    - a. Include dimensioned plan and elevation, front and side views and any other pertinent elevation views
    - b. Knock-out or punching information.
  - 2. Equipment Panels: Include wiring schematic diagram, wiring diagram, outline drawing and construction diagram as described in ANSI/NEMA ICS 1.
  - 3. Closeout: Submittals listed above, updated to record status.

**PART 2 – PRODUCTS****2.1 HINGED COVER ENCLOSURES:**

- A. Construction:
  - 1. NEMA 250
  - 2. Type 1, steel.
- B. Components: 14 gauge steel, white enamel finish.
- C. Finish: Manufacturer's standard enamel finish.
- D. Covers:
  - 1. Continuous hinge
  - 2. Held closed by flush latch operable by key.
- E. Panel for Mounting Terminal Blocks or Electrical devices

**2.2 CABINETS:**

- A. Cabinet Boxes:
  - 1. Galvanized steel with removable endwalls

2. 24 inches wide by 6 inches deep.
- B. Cabinet Fronts:
1. Steel
  2. Surface type with concealed hinge and flush lock keyed separately for each system
  3. Finish in gray baked enamel.

**2.3 TERMINAL BLOCKS AND ACCESSORIES:**

- A. Terminal Blocks:
  - 1. ANSI/NEMA ICS 4
  - 2. UL listed.
- B. Power Terminals:
  - 1. Unit construction type
  - 2. Closed-back type
  - 3. Tubular pressure screw connectors
  - 4. Rated 600 volts.
- C. Signal and Control Terminals:
  - 1. Modular construction type
  - 2. Channel mounted
  - 3. Tubular pressure screw connectors
  - 4. Rated 300 volts.

**2.4 BACKBOARD:**

Unpainted 3/4 inch thick fire rated plywood backboard for mounting cabinet terminal blocks.

**PART 3 - EXECUTION****3.1 FABRICATION:**

- A. Shop assemble enclosures and cabinets housing terminal blocks or electrical components in accordance with ANSI/NEMA ICS 6.
- B. Provide knockouts on enclosures.
- C. Provide protective pocket inside front cover with schematic diagram, connection diagram, and layout drawing of control wiring and components within enclosures.

**3.2 INSTALLATION:**

- A. Install cabinets, enclosures, and trim plumb and square with building lines.
- B. Anchor securely to wall and structural supports at each corner, minimum.
- C. Provide accessory feet for free-standing equipment enclosures.

**END OF SECTION 26 27 16**

**SECTION 26 27 26 - WIRING DEVICES****PART 1 - GENERAL****1.1 SUMMARY:**

- A. The extent of wiring device work is indicated by drawings and schedules. Wiring devices are defined as single discrete units of electrical distribution systems which are intended to carry but not utilize electric energy.
- B. Types of electrical wiring devices in this section include the following:
  - 1. Receptacles.
  - 2. Ground-fault circuit interrupters.
  - 3. Switches.
  - 4. Wallplates (steel, only).
  - 5. Dimmers.
  - 6. Plugs and connectors.
  - 7. Concrete floor boxes (poke-through, only).
  - 8. Poke-through assemblies.
  - 9. Telephone/power poles.
  - 10. Access floor boxes.
  - 11. Transient Voltage Surge Suppressor Receptacles.

**1.2 QUALITY ASSURANCE:**

- A. **Manufacturers:** Firms regularly engaged in manufacture of electrical wiring devices, of types, sizes and ratings required, whose products have been in satisfactory use in similar service for not less than 3 years.
- B. **Installer's Qualifications:** Firm with at least 2 years of successful installation experience on projects utilizing wiring devices similar to those required for this project.
- C. **Listing and Labeling:** Provide products that are listed and labeled for their applications and installation conditions and for the environments in which installed.

- D. The Terms "Listed" and "Labeled": As defined in the "National Electrical Code", Article 100.
- E. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

### 1.3 SUBMITTALS:

- A. Product Data: Submit manufacturer's data on electrical wiring devices.
- B. Samples of device plates for color selection and evaluation of technical features shall be submitted.
- C. Operation and maintenance data for materials and products specified in this Section to include in the "Operating and Maintenance Manual" specified in the General Conditions of the Contract and other Division 26 sections.

### 1.4 COORDINATION:

- A. Wiring Devices for Owner Furnished Equipment: Match devices to plug connectors for Owner-furnished equipment.
- B. Cord and Plug sets: Match cord and plug sets to equipment requirements.

### 1.5 EXTRA MATERIALS:

- A. Furnish the following extra materials, packaged with protective covering for storage, and identified with labels describing contents. Deliver extra materials to the Owner.
- B. Telephone/Power Service Poles: 1 for each 10, but not less than 1.
- C. Floor Service Outlet Assemblies: 1 for each 10, but not less than 1.
- D. Poke-through Fire-Rated Closure Plugs: 1 for each 5 floor service outlets installed, but not less than 2.
- E. Transient-Voltage Surge-Suppressor Receptacles: 1 for each 8 installed, but not less than 2.

## PART 2 - PRODUCTS

### 2.1 ACCEPTABLE MANUFACTURERS:

- A. Manufacturers: Subject to compliance with requirements, provide devices from one of the following:
  - 1. Devices (steel, only):

- a. Hubbell Inc.
  - b. Leviton Mfg Co.
  - c. Mulberry (device plates)
  - d. Stenco (device plates)
  - e. Pass and Seymour Inc.
  - f. Cooper Crouse-Hinds Co.
  - g. Bryant Electric Co.
  - h. General Electric Co.
2. Concrete Floor Boxes:
- a. Hubbell Inc.
  - b. Wiremold
  - c. Walker
3. Access Floor Boxes (poke-through, only):
- a. Hubbell
  - b. Wiremold
  - c. Walker
  - d. Raceway Components
  - e. Donn
  - f. Midland Ross
  - g. Tate
4. Wiring Devices for Hazardous (Classified) Locations:
- a. Crouse-Hinds Electrical Construction.
  - b. Killark Electrical Mfg. Co.
  - c. Pyle-National Co.



5. Poke-Through, Floor Service Outlets, and Telephone/Power Poles:
  - a. Hubbell, Inc.
  - b. Wiremold Co.
  - c. Walker Div., Butler Mfg. Co.
  - d. American Electric
  - e. Pass & Seymour/LeGrand
  - f. Square D Co.

## 2.2 WIRING DEVICES:

### A. Receptacles:

1. All duplex, single, and special receptacles shall be heavy duty, specification grade, listed by Underwriter's Laboratories, have a metal mounting strap with self-grounding and have a hex-head green grounding screw and be side and back wired. Each device shall bear the UL/FS Label.
  - a. Each device shall have terminal screws and clamps listed for use with stranded wire.
2. Convenience Receptacle Configuration: NEMA WD 1; Type 5-20R, with ivory metal face. All receptacles connected to emergency circuits (when applicable) shall have a red face. Color selection shall be verified with Architect/Engineer prior to ordering.
3. Specific-use Receptacle Configuration: NEMA WD 1; straight blade OR WD 5 locking; as indicated on drawings, black face.
4. Safety Receptacles: Duplex receptacle with integral switch and contacts to prevent energizing unless a plug is inserted. Specification grade metal face: ivory for normal, red for emergency (when applicable).
5. Ground-Fault Interrupter Receptacles: Provide "feed-thru" type ground-fault circuit interrupters, with integral heavy-duty NEMA 5-20R duplex receptacles, capable of protecting connected downstream receptacles on same circuit. Provide unit capable of being installed in a 2-3/4" deep outlet box without adapter, grounding type, Class A, Group 1 per UL Standard 943.
6. Clock Outlet: Single NEMA 5-15P side wired plug mounted in a recessed faceplate with metal hook which permits clock to be flush mounted on wall.

7. Transient-Voltage Surge-Suppressor (TVSS) Receptacles: Duplex type, NEMA 5-20R configuration with integral transient-voltage surge protection in a minimum of 3 modes: line-to-ground, line-to-neutral, neutral-to-ground; listed as complying with UL Standard 1449 "Transient Voltage Surge Suppressors."
  - a. Surge Protection Components: Multiple metal-oxide varistors, rated for 500 V transient suppression voltage nominal clamp level and minimum single transient pulse energy dissipation of 140 J, line-to-neutral, and 70 J, line-to-ground and neutral-to-ground.
  - b. Active Protection Indication: A light visible in the face of the device indicates the state of the device as "active" or "inactive."
  - c. Identification: Distinctive marking on face of device denotes transient-voltage surge-suppressor type unit.
8. Receptacles, Industrial Heavy-Duty: Conform to NEMA Standard PK 4 "Plugs, Receptacles, and Cable Connectors of the Pin and Sleeve Type for Industrial Use."
9. Receptacles in Hazardous (Classified) Locations: Comply with NEMA Standard FB 11 "Plugs, Receptacles and Connectors on the Pin and Sleeve Type for Hazardous Locations" and UL Standard 1010 "Receptacle-Plug Combinations for Use in Hazardous (Classified locations)."
10. Pendant Cord/Connector Devices: Matching, locking type, cord and plug receptacle body connector, NEMA L5-20P and L5-20R, heavy-duty grade.
  - a. Bodies: Nylon with screw-open, cable-gripping jaws and provision for attaching external cable grip.
  - b. External Cable Grip: Woven wire mesh type made of high strength galvanized-steel wire strand and matched to cable diameter with attached provision for the corresponding connector.
11. Cord and Plug Sets: Match voltage and current ratings and number of conductors to requirements of the equipment being connected.
  - a. Cord: Rubber-insulated, stranded copper conductors, with type-SOW-A jacket. Grounding conductor has green insulation. Ampacity is equipment rating plus 30%, minimum.
  - b. Plug: Male configuration with nylon body and integral cable-clamping jaws. Match to cord and receptacle type intended for connection.

B. Switches:

1. Wall Switches for Lighting Circuits: NEMA WD1; FS W-S-896E; AC quiet type specification grade listed by Underwriter's Laboratories with toggle handle, rated 20 amperes at 120-277 volts AC, unless noted otherwise. Mounting straps shall be metal and be equipped with a green hex-head ground screw. Each switch shall bear the UL/FS Label.
  - a. Each device shall have terminal screws and clamps listed for use with stranded wire.
2. Handle: Ivory for normal power circuits, red for emergency power circuits (when applicable). Verify color with Architect/Engineer prior to ordering.
3. Pilot Light Type: Lighted handle lit when switch is "on."
4. Locator Type: Continuously lighted handle.
5. Switches in Hazardous (Classified) Locations: Comply with UL Standard 894, "Switches for Use in Hazardous (Classified) Locations."
6. Combination Devices: Provide heavy-duty quiet type switch, 20-amperes, 120-277 volts AC, with toggle switch handle, and 3-wire grounding receptacle, 20-amperes, 120- volts, in a common 4 inch square box.
7. Incandescent Lamp Dimmers: Provide branch lighting solid-state AC dimmer controls for incandescent lighting; wattage as indicated, 120-volts, 60-Hz, with continuously adjustable slide dimmer, white nylon face, and single-pole with integral ON-OFF switch. Equip with electromagnetic filters to eliminate noise, RF and TV interference, and with 5-inch wire connecting leads. Dimmer shall be Lutron Nova "T" Star NT-Series for single pole and NTB/NTA Series for 3-way dimming with NTETS-R electronic touch switch for auxiliary ON-OFF control. Low voltage dimmer shall be NTLV Series.
8. Fluorescent Lamp Dimmers: Provide single-pole, full-wave semi-conductor modular type AC dimmers for fluorescent lamps; wattage and voltage as indicated, and with electromagnetic filters to reduce noise, RF and TV interference to minimum. Construct with continuously adjustable trim potentiometer for adjustment of low dimming; and with anodized heat sinks. Provide 5-inch wire connecting leads. Dimmers shall be Lutron, only.

### 2.3 WIRING DEVICE ACCESSORIES:

- A. Wallplates: Provide wallplates for single and combination wiring devices, of types, sizes, and with ganging and cutouts as indicated. Select plates which mate and match wiring devices to which attached. Install with metal screws for securing plates to devices; screw heads colored

to match finish of plates. Identify all wall plates used for receptacles with branch circuit number per requirements of Section 26 05 53 on Electrical Identification. Provide blank wall plates for all cable, data, telephone and junction and outlet boxes. Where cables are routed through the wallplate, provide grommets in wallplate openings to protect cables. Provide plates possessing the following additional construction features:

1. Material and Finish: Stainless steel type 302 satin finished 0.04" thick in kitchens, laboratories, restrooms and similar environments.
  2. Material and Finish: Galvanized steel plate for use in unfinished areas, custodial spaces, mechanical and electrical rooms.
  3. Material and Finish: Smooth, ivory-finished metal (except as otherwise noted) plates in offices, classrooms, conference rooms and other finished spaces.
- B. Concrete Floor Box: Provide modular floor service outlets and fittings of types and ratings indicated. Construct of die cast aluminum, satin finish. Use design compatible with floor type and outlet wiring methods indicated. Provide 20-amperes, 125-volts, back-to-back duplex receptacles, NEMA configuration 5-20R. Provide with 1" NPT, 1" long, locking nipple for installation.
- C. Poke-Through Assembly Devices: Factory-fabricated poke-through assembly devices with modular service outlets, multi-channeled thru-floor raceway/fire stop assembly and below-floor junction box assembly. Construct service fitting of die cast, satin finished aluminum with 20-ampere 120-volts, gray duplex NEMA 5-20R receptacle and modular communication/ data service outlet with separation barrier between power and low-tension section. Provide integral assembly UL listed as a total unit, with fire rating consistent with that of floor penetrated.
- D. Telephone/Power Poles: Provide factory-assembled telephone/power poles of types, sizes and ratings indicated; for use with telephone, data, and power systems installed above suspended ceilings. Construct with provisions for two 50-pair telephone cables, two data outlets and cables, and 2, 20-amperes, 125-volts, 3-wire duplex receptacles. Isolate power section from telephone compartment with separating steel enclosure. Extend wiring from receptacles to junction box at top of pole where connections are made above suspended ceiling. Provide pole foot with carpet pad; provide ceiling trim plate. Provide finish treatment and color as selected by Architect/Engineer.

## PART 3 - EXECUTION

### 3.1 INSTALLATION OF WIRING DEVICES:

- A. Install wiring devices as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC and in accordance with recognized industry practices to fulfill project requirements.

- B. Coordinate with other work, including painting, electrical boxes and wiring work, as necessary to interface installation of wiring devices with other work.
- C. Install wiring devices only in electrical boxes which are clean; free from excess building materials, dirt and debris.
- D. Install wiring devices after wiring work is completed.
- E. Install wallplates after painting work is completed.
- F. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturers published torque values for wiring devices. Where manufacturer's torque requirements are not indicated, tighten connectors and terminals to comply with torque values specified in UL Standards 486A.
- G. Install telephone/power service poles in accordance with final furnishing arrangement. Poles shall be plumb, true, and secure.
- H. Provide GFCI type outlets for each above counter duplex receptacle shown within 6 feet-0 inches of sinks/lavatories. For above counter multi-outlet assemblies which do not contain duplex receptacles that can be replaced with GFCI devices, provide GFI circuit breakers on the branch circuit(s) feeding the assembly.
- I. Provide safety type receptacles in areas indicated on drawings (when applicable).
- J. Provide GFCI receptacles throughout in kitchens and at vending machines.

### 3.2 PROTECTION OF WALLPLATES AND RECEPTACLES:

- A. Upon installation of wallplates and receptacles, advise Contractor regarding proper and cautious use of convenience outlets. Prior to Final Completion, replace those items which have been damaged, including those burned and scored by faulty plugs.

### 3.3 GROUNDING:

- A. Provide equipment grounding connections for wiring devices, unless otherwise indicated. Tighten connections to comply with torque values specified in UL Std 486A to assure permanent and effective grounds.

### 3.4 CLEANING:

- A. Internally clean devices, device outlet boxes and enclosures. Replace stained or improperly painted wall plates or devices.

### 3.5 TESTING:

- A. Prior to energizing circuitry, test wiring for electrical continuity, and for short-circuits. Ensure proper polarity of connections is maintained. Subsequent to energizing, test wiring devices to demonstrate compliance with requirements. Operate each operable device at least six (6) times.
- B. Test ground fault interrupter operation with both local and remote fault simulations in accordance with manufacturer recommendations.
- C. TVSS receptacle indicating lights for normal indication check.
- D. Replace damaged or defective components.

**END OF SECTION 26 27 26**

**SECTION 26 28 00 - OVERCURRENT PROTECTIVE DEVICES**

## PART 1- GENERAL

## 1.1 SUMMARY:

- A. This Section includes overcurrent protective devices (OCPD's) rated 600 V and below and switching devices commonly used with them.
- B. Panelboards, Switchboards, and Motor Control Centers: Application, installation, and other related requirements for overcurrent protective device installations in distribution equipment are specified in other Division 26 sections.

## 1.2 DEFINITIONS:

- A. Overcurrent Protective Device (OCPD): A device operative on excessive current that causes and maintains the interruption of power in the circuit it protects.
- B. Ampere-Squared-Seconds: An expression of available thermal energy resulting from current flow. With regard to current-limiting fuses and circuit breakers, the ampere-squared-seconds during fault current interruption represents the energy allowed to flow before the fuse or breaker interrupts the fault current within its current limiting range.

## 1.3 SUBMITTALS:

- A. Product data for fuses, fusible switches, circuit breakers, and OCPD accessories specified in this Section, including descriptive data and time-current curves for all protective devices and let-through current curves for those with current limiting characteristics. Include coordination charts and tables and related data.
- B. Provide coordination study performed by a registered professional engineer in accordance with ANSI/IEEE Standard 242-1986, "Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems, where OCPD manufacturers other than those designated first in schedules or product listings of overcurrent protective devices are proposed for use. Submit a full coordination study showing graphically that the substitute OCPD's coordinate selectively with both upstream and downstream components. Include single line diagram, coordinated time-current characteristics, device performance curves, and fault current calculations adequate to demonstrate satisfactory component protection and selective coordination of protective devices. Study shall be commissioned and paid for by the Contractor. Submit study with switchgear, switchboard and panelboard submittals.

## 1.4 QUALITY ASSURANCE:

- A. Manufacturers: Firms regularly engaged in manufacture of overcurrent protective devices of types, sizes, and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Each type of OCPD shall be the product of a single manufacturer.

**1.5 EXTRA MATERIALS:**

- A. Spare Fuses: Furnish spares of each type and rating of fuse for fusible devices amounting to one set of 3 fuses for each 9 fuses installed but not less than 3 fuses of each type.

**PART 2 - PRODUCTS:**

**2.1 MANUFACTURERS:**

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
  - 1. Cartridge Fuses:
    - a. Eaton
    - b. Bussmann Div., Cooper Industries, Inc.
    - c. Littelfuse Inc.
  - 2. Fusible Switches:
    - a. General Electric Co.
    - b. Siemens Energy & Automation, Inc.
    - c. Square D Co.
    - d. Westinghouse
    - e. Eaton
    - f. Cutler-Hammer, Inc.
    - g. Allen-Bradley Co.
  - 3. Fused Power Circuit Devices:
    - a. General Electric Co.
    - b. Square D Co.



- c. Eaton
- 4. Molded-Case Circuit Breakers:
  - a. General Electric Co.
  - b. Siemens Energy & Automation, Inc.
  - c. Square D Co.
  - d. Westinghouse
  - e. Eaton
  - f. Cutler-Hammer, Inc.
- 5. Combination Circuit Breaker and Ground Fault Circuit Interrupters:
  - a. General Electric Co.
  - b. Siemens Energy & Automation, Inc.
  - c. Square D Co.
  - d. Westinghouse
  - e. Eaton
  - f. Cutler-Hammer, Inc.
- 6. Molded-Case Current-Limiting Circuit Breakers:
  - a. General Electric Co.
  - b. Siemens Energy & Automation, Inc.
  - c. Square D Co.
  - d. Westinghouse
  - e. Eaton
  - f. Cutler-Hammer, Inc.
- 7. Integrally Fused Molded-Case Circuit Breakers:
  - a. General Electric Co.
  - b. Siemens Energy & Automation, Inc.
  - c. Square D Co.

- d. Westinghouse
  - e. Eaton
  - f. Cutler-Hammer, Inc.
8. Insulated Case Circuit Breakers:
- a. General Electric Co.
  - b. Siemens Energy & Automation, Inc.
  - c. Square D Co.
  - d. Westinghouse
  - e. Eaton
  - f. Cutler-Hammer, Inc.
9. Power Circuit Breakers:
- a. General Electric Co.
  - b. Siemens Energy & Automation, Inc.
  - c. Square D Co.
  - d. Westinghouse
  - e. Eaton
  - f. Cutler-Hammer, Inc.
- B. When Mounting overcurrent protective devices in switchboards, switchgear, panelboards, MCC's, etc., provide equipment of same manufacturer as equipment into which they are being mounted.

**2.2 OVERCURRENT PROTECTIVE DEVICES (OCPDS), GENERAL:**

- A. General: Provide OCPDs in indicated types, as integral components of panelboards, switchboards, motor control centers, and other related equipment; and also as individually enclosed and mounted single units.
- B. Enclosures: NEMA 250 "Enclosures for Electrical Equipment (1,000 Volts Maximum)."
- C. Where OCPD's are to be installed in existing panelboards, switchboards, and motor control centers, they shall be of the same manufacture and type as those existing in the

equipment. If this is not possible, provide devices which are compatible with the existing equipment and when installed will not void the U.L. label or reduce the short circuit rating of the equipment.

- D. Provide 100 percent rated equipment and feeder breakers unless otherwise noted.
- E. Provide standard rated branch circuit breakers unless otherwise noted.
- F. All overcurrent devices shall be individually rated for the available fault current unless otherwise noted. Series ratings of equipment will only be allowed where specifically called out.

### 2.3 CARTRIDGE FUSES:

- A. General: NEMA Standard FU1, "Low-Voltage Cartridge Fuses." Unless indicated otherwise, provide nonrenewable cartridge fuses of indicated types, classes, and current ratings that have voltage ratings consistent with the circuits on which used.
- B. All fuses used for main, feeder, or branch-circuit protection shall be Underwriters Laboratories listed, current-limiting fuses with 200,000 ampere interrupting rating and shall be so labeled. Fuses used for supplementary protection (other than branch circuit protection) shall be as specified above or shall be U.L. approved or component recognized for such purposes. All fuses provided shall be furnished by the same manufacturer. Should equipment provided require a different U.L. Class or size of fuse, the engineer shall be furnished sufficient data to ascertain that system function will not be adversely affected.
- C. In order to simplify fuse replacement, reduce spare fuse inventory and insure adequate thermal protection, all fuses 600 amperes and below shall be true dual-element time-delay fuses with separate spring-loaded thermal overload elements in all ampere ratings. All ampere ratings shall be designed to open at 400 degrees F or less when subjected to a non-load oven test.
- D. To eliminate induction heating, all fuse ferrules and end caps shall be non-ferrous and shall be bronze or other alloy not subject to stress cracking.
- E. Class L Fuses: UL 198C, "High-Interrupting Capacity Fuses, Current-Limiting Type."
- F. Class RK1 and RK5 Dual Element Time-Delay Fuses: UL 198E, "Class R Fuses."
- G. Class J Low-Peak dual Element Fuse: UL 198C

### 2.4 NONFUSIBLE SWITCHES:

- A. General: UL 98 "Enclosed and Dead Front Switches" and NEMA KS 1 "Enclosed Switches," quick-make, quick-break heavy-duty units.

- B. Rating: Load-breaking capacity in excess of the normal horsepower rating for the switch.
- C. Withstand Capability: In excess of the available.
- D. Operation: By means of external handle.
- E. Interlock: Prevents access to switch interior except when in "off" position.
- F. Enclosure for Independent Mounting: NEMA Type 1 enclosure except as otherwise indicated or required to suit environment where located.
- G. Contacts shall be NEMA rated 75 degrees C.
- H. Provide auxiliary contacts for disconnects supplied from variable frequency drives.

#### 2.5 FUSIBLE SWITCHES:

- A. General: UL 98 "Enclosed and Dead Front Switches" and NEMA KS 1 "Enclosed Switches," quick-make, quick-break heavy-duty units.
- B. Rating: Load-breaking capacity in excess of the normal horsepower rating for the switch.
- C. Withstand Capability: In excess of the let-through current permitted by its fuse when subject to faults up to 100,000 RMS symmetrical amperes.
- D. Operation: By means of external handle.
- E. Interlock: Prevents access to switch interior except when in "off" position.
- F. Fuse Clips: Rejection type.
- G. Enclosure for Switchboard or Panel board Mounting: Suitable for panel mounting where indicated.
- H. Enclosure for Independent Mounting: Provide NEMA Type 1 enclosure except as otherwise indicated or required to suit environment where located.
- I. Contacts shall be NEMA rated 75 degrees C.
- J. Provide fuses for safety switches and other equipment of classes, types, and rating needed to fulfill electrical requirements for services indicated.
- K. Provide auxiliary contacts for disconnects supplied from variable frequency drives.

#### 2.6 FUSED POWER CIRCUIT DEVICES:

- A. General: UL 977, "Fused Power Circuit Devices," with either bolted-pressure-type or high-pressure contact-type switch.
- B. Operation: Manually closed, electrically tripped.

OR

Manually opened and closed.

OR

Electrically closed and tripped.

- C. Ground Fault Protection: Integral, self-powered type with mechanical ground fault indicator, test function, adjustable pick-up current and delay time with inverse and constant time characteristics, internal memory arranged to integrate intermittent arcing ground faults, and ground fault current sensor located as indicated.
- D. Open Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.
- E. Enclosure for Switchboard Mounting: Suitable for individual mounting.
- F. Enclosure for Independent Mounting: NEMA Type 1 enclosure, except as indicated or except as required to suit environment where located.
- G. Minimum Fault Current Rating: As indicated.

#### 2.7 MOLDED-CASE CIRCUIT BREAKERS:

- A. General: UL 489, "Molded Case Circuit Breakers and Circuit Breaker Enclosures," and NEMA AB 1, "Molded Case Circuit Breakers."
- B. Construction: Provide bolt-in type, except breakers 225-ampere frame size and larger which may be plug-in type if held in place by positive locking device requiring mechanical release for removal.
- C. Characteristics: Indicated frame size, trip rating, number of poles, and a short-circuit interrupting capacity rating as indicated or required to match existing devices or equipment.
- D. Tripping Device: Quick-make, quick-break toggle mechanism with inverse-time delay and instantaneous overcurrent trip protection for each pole. Trip unit to be interchangeable within frame sizes for breakers 200 amperes or larger. Breakers 150 amperes and above shall have adjustable trip selection for trip units. All 120/208 volt rated breakers shall be rated and labeled "High Magnetic".

- E. Adjustable Instantaneous Trip Devices: Factory adjusted to low-trip-setting current values. Provide adjustable instantaneous trip devices for each circuit breaker supplying individual motor loads and where indicated.
- F. Enclosure for Switchboard or Panelboard Mounting: Suitable for panel mounting in switchboard or panelboards where indicated.
- G. Enclosure for Switchboard or Motor Control Center Mounting: Provide individual mounting where indicated.
- H. Enclosure for Independent Mounting: NEMA Type 1 enclosure, except as otherwise indicated or required to suit environment where located.

#### 2.8 COMBINATION CIRCUIT BREAKERS AND GROUND FAULT CIRCUIT INTERRUPTERS:

- A. General: UL 943 "Ground Fault Circuit Interrupters," arranged for sensing and tripping for ground fault current in addition to overcurrent and short-circuit current. Provide features as follows:
- B. Match features and module size of panelboard breakers and provide clear identification of ground fault trip function.
- C. Trip Setting for Ground Fault: 4 to 6 milli-amperes, listed and labeled as a class A, type 1 device.

#### 2.9 CURRENT-LIMITING CIRCUIT BREAKERS:

- A. General: Arranged to limit let-through ampere-squared-seconds during fault conditions to a value less than the ampere-squared-seconds of one-half-cycle wave of the prospective symmetrical fault current. The circuit breaker shall use no fusible devices in its operation. The current-limiting characteristic shall be in addition to normal time-delay and instantaneous-trip characteristics and other features as indicated.

#### 2.10 INTEGRALLY FUSED CIRCUIT BREAKERS:

- A. General: Arranged to limit let-through ampere-squared-seconds during fault conditions to a value less than the ampere-squared-seconds of one-half-cycle wave of the prospective symmetrical fault current. The current-limiting characteristic shall be achieved through the use of replaceable current-limiting fuses internally mounted within the circuit-breaker case. The opening of any one fuse shall trip all poles of the circuit breaker. For each trip rating the time-current characteristic of the fuses shall be coordinated with that of the normal inverse-time and instantaneous-trip devices of the

circuit breaker so current-limiting fuse melting does not occur for faults within the interrupting rating of the basic breaker.

#### 2.11 CIRCUIT BREAKERS WITH SOLID-STATE TRIP DEVICES:

- A. General: Provide indicated circuit breakers with solid-state trip devices having the following features:
  - 1. Ambient Compensation: Trip device insensitive to temperature changes between minus 20 degrees C and plus 55 degrees C.
  - 2. Adjustability: Breaker ratings and trip settings shall be changeable by operation of controls on front panel of breaker, by change of plug-in element without removing breaker from mounting, or by a combination of the two methods.
    - a. The trip device sensor shall have the same rating as the frame amperage of the circuit breaker unless noted otherwise.
  - 3. Ground-Fault Tripping: Adjustable for pick-up and time-delay values. Provide for indicated units.

#### 2.12 INSULATED-CASE CIRCUIT BREAKERS:

- A. General: UL 489, "Molded-Case Circuit Breakers and Circuit Breaker Enclosures," and NEMA AB 1, "Molded-Case Circuit Breakers."
- B. Ratings: Continuous-current, interrupting, and short-time-current ratings, and voltage and frequency ratings as indicated. Provide breakers with short time ratings above available fault levels.
- C. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:
  - 1. Moving Contacts Closing Speed: Independent of both control and operator.
  - 2. Stored-Energy Mechanism: Manually charged.
  - 3. Stored-Energy Mechanism: Electrically charged, with provision for optional manual charging.
  - 4. Operation Counter: Include except as otherwise indicated.
- D. Circuit-Breaker Trip Devices: Solid-state overcurrent trip device system that includes one integrally mounted current transformer or sensor per phase, a release mechanism, and the following features:

1. Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, which are independent of each other in both action and adjustment.
  2. Temperature compensation to assure accuracy and calibration stability from minus 20 degrees C to plus 55 degrees C.
  3. Field-adjustable, time-current characteristics.
  4. Current Adjustability: Effected by operating controls on front panel or by changing plug-in elements or current transformers or sensors.
  5. Five pickup points, minimum, for long-time- and short-time-trip functions.
  6. Six pickup points, minimum, for instantaneous-trip functions.
  7. Ground fault protection with at least three short-time-delay settings and three trip-time-delay bands. Adjustable current pickup.
  8. Trip Indication: Labeled lights or mechanical indicators on trip device shall indicate type of fault causing breaker trip. If lights are used, integral power source shall maintain indication for 60 hours, minimum.
- E. Auxiliary Contacts for Remote Indication: Where remote indication of breaker position is indicated, provide a spare auxiliary switch in addition to other auxiliary switches required for normal breaker operation. The spare auxiliary switch shall consist of two Type "a" and two Type "b" stages (contacts), wired to a terminal block in the breaker housing.
- F. Drawout Features: Circuit-breaker mounting assembly equipped with a racking mechanism that properly positions the power circuit breaker and holds it rigidly in connected, test, and fully disconnected positions and includes the following features:
1. Interlock arrangement, preventing movement of the circuit breaker to or from the connected position when it is in the closed position and closure of the circuit breaker unless it is in the connected, test, or disconnected position.
  2. Construction, permitting racking an open circuit breaker to or from the connected, test, and disconnected positions with the associated compartment door closed or equivalent dead-front barrier protection, and manual withdrawal to a position for removal from the structure with the door open.
  3. Primary disconnecting devices disengaged and secondary disconnecting devices engaged when breaker is in test position.



4. Primary and secondary devices disengaged when circuit breaker is in the disconnected position.
  5. Ground contact engaged when the circuit-breaker element is in the connected and test positions.
- G. Circuit-Breaker Features and Accessories: Include the following:
1. Operating Handle: Provide one for each manually operated breaker.
  2. Electric Close Button: Provide one for each electrically operated breaker.
  3. Indicating Lights: Contacts for "Breaker Open" and "Breaker Closed," for main and bus tie circuit breakers, and for other indicated breakers.

### 2.13 POWER CIRCUIT BREAKERS:

- A. General: Separate sections shall be provided for each breaker. An individual power circuit breaker compartment and associated drawout current limiting fuses shall be provided for each breaker as shown. The master control compartment shall be located above the main utility circuit breaker compartments and shall contain the associated protective relaying, load bus voltmeter, load bus ampere meter, load bus kilowatt, kilovar meters, power factor meters and associated meter selector switches.
- B. Low Voltage Power Circuit Breaker: Furnish and install each breaker to provide overcurrent protection and transitioning functions. The breaker shall be rated for frame, trip and AIC as shown on drawings, 3-pole, single throw, 100 percent rated electrically operated, large air, dead front, drawout type with solid-state trip elements. The use of insulated case type circuit breakers shall not be permitted.
1. Breakers shall have 5-cycle, stored energy closing.
  2. Drawout feature shall provide for connected, test, and disconnected positions.
    - a. In the connected position, the main line and load terminals and all auxiliary control contacts and circuitry shall be connected and the breaker shall be fully operable.
    - b. In the test position, the breaker auxiliary control contacts and circuitry only shall be connected to permit automatic operation of the complete control system without actually connecting the load or source to the main bus.
    - c. In the disconnected position, main and auxiliary control contacts and circuitry shall be completely disconnected.

3. The breaker drawout mechanism shall be mechanically interlocked with the breaker to permit drawout operation only when the breaker main contacts are open.
  4. If a separate fuse compartment is provided, the fuse drawout tray shall be interlocked mechanically to the breaker.
  5. Provide integral "Open" and "Close" operating buttons on each breaker. Provide "open", "close", and "tripped" position indicators.
  6. A shutter shall automatically close the opening to the insulators for the primary disconnecting devices when the circuit breaker unit reaches the "disconnect" position. The shutter shall be a simple, one-piece unit, closed by gravity and raised automatically upon insertion of the air circuit breaker.
  7. Trip elements shall include the following adjustable settings:
    - a. Long time pick up
    - b. Long time delay
    - c. Short time pick up
    - d. Short time delay
    - e. Instantaneous pick up
    - f. Ground fault
- C. The breaker operating mechanism shall be of the two-step, stored energy, quick-make/quick-break type. Operating the charging handle or one operation cycle of the breaker motor shall charge the closing springs. A separate operation of the breaker manual "close" button shall close the breaker contacts. Closing of the breaker contacts shall automatically charge the opening springs to insure quick-break operation. Provide for manual charging for breaker operation.
- D. Padlocking provisions shall be furnished to receive up to three padlocks when the breaker is "open" and in the "disconnected" position, positively preventing unauthorized closing of the breaker contacts.
- E. Provide a manual "trip" button, drawout position indicator, contact position indicator and spring condition indicator on the breaker.
- F. Provide one extra four-stage, auxiliary switch and one extra eight-stage, cell-mounted, auxiliary switch, mechanism operated (MOC). When in the test position, the interlocks shall be bypassed.

- G. Provide testing, calibration, and certification of the breaker by an independent NETA certified, testing consultant. The breakers shall be UL listed and labeled.
- H. The bus/cable compartment in the rear of each housing shall be provided with sleeves or Micarta supports for power bus/cables. The compartment shall be arranged for the bus/cables to enter from the top or bottom as shown or required. Rear access type switchgear shall be required.
- I. The stationary structure and circuit breaker units shall be constructed so that each circuit breaker unit is interchangeable with every unit of similar rating.
- J. Provide necessary copper bussing, AIC bracing as indicated with full neutral and properly sized ground bus. Rate breaker maximum short time setting above available fault level.
- K. Provide dead bus relays 120VAC coil powered from internal and external source for logic purposes.

#### 2.14 OCPD ACCESSORIES:

- A. Key Interlocks: Arrange interlocking so keys are held captive at devices indicated. Where future key interlocking provisions are indicated, provide necessary mountings and hardware as required for the future installation.
- B. Provide adjustable-time-delay under-voltage trip devices where indicated.
- C. Provide shunt-trip devices for Circuit breakers unless otherwise indicated. Arrange to trip breaker from an external source of power through a control switch or relay contact.
- D. Provide bell alarm contacts for tripped position.
- E. Lock-Out Devices: Provide padlocking provisions on each overcurrent protective device, lockable in the open or closed position. Provide 3 sets of lockout/tagout devices for each type of breaker or switch provided. Include tags, locks and all accessories necessary.
- F. Provide hand held battery powered trip unit power supply with labeled storage compartment for each switchboard.

#### 2.15 SPARE FUSE CABINET:

- A. Cabinet: Wall-mounted, 18-gauge minimum steel unit with full-length, recessed piano-hinged door with key-coded cam lock and pull. Size to be adequate for orderly storage of spare fuses specified with 15 percent spare capacity minimum. Cabinet finish: gray baked enamel. Stencil legend "SPARE PARTS" in 1-1/2 inches (40-mm) letters on door.

**PART 3 - EXECUTION:****3.1 INSTALLATION:**

- A. Independently Mounted OCPDs: Locate as indicated and install in accordance with manufacturer's written installation instructions. Install OCPDs level and plumb.
- B. OCPDs in new distribution and branch circuit equipment shall be factory installed. OCPD's in existing distribution and branch circuit equipment shall match existing for type and be provided with features as listed herein.
- C. Install fuses in fusible devices as indicated. Arrange fuses so that fuse ratings are readable without removing fuse.
- D. All fuses for new disconnect switches or MCC's feeding motors or motor starters shall be provided with Class J fuses.

**3.2 IDENTIFICATION:**

- A. Identify components in accordance with Division 26 Section on electrical identification.

**3.3 CONTROL WIRING INSTALLATION:**

- A. Install wiring between OCPDs and control/indication devices.

**3.4 CONNECTIONS:**

- A. Check connectors, terminals, bus joints, and mountings for tightness. Tighten field-connected connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque values. Where manufacturer's torque requirements are not indicated, tighten connectors and terminals to comply with torque values specified in UL 486A and UL 486B.

**3.5 GROUNDING:**

- A. Provide equipment grounding connections for individually mounted OCPD units as indicated and as required by NEC. Tighten connectors to comply with torque values specified in UL Standard 486A to assure permanent and effective grounding.

**3.6 FIELD QUALITY CONTROL:**

- A. Reports: Prepare written reports on tests and observations. Report defective materials and workmanship and unsatisfactory test results. Include complete records of repairs and adjustments made. Tests shall be made on all new and existing OCPD's provided and/or connected under this project in accordance with this section.

- B. Labeling: Upon satisfactory completion of tests and related effort, apply a label to tested components indicating test results, date, and responsible organization and person.
- C. Schedule visual and mechanical inspections and electrical tests with at least one week advance notification.
- D. Upon completing installation of the system, perform the following tests:
  - 1. Visual and mechanical inspection: Include the following inspections and related work.
    - a. Overcurrent-Protective-Device Ratings and Settings: Verify indicated ratings and settings to be appropriate for final system arrangement and parameters.
    - b. Inspect for defects and physical damage, NRTL labeling, and nameplate compliance with current single line diagram.
    - c. Exercise and perform operational tests of all mechanical components and other operable devices in accordance with manufacturer's instruction manual.
    - d. Check tightness of electrical connections of OCPD's with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.
    - e. Clean OCPD's using manufacturer's approved methods and materials.
    - f. Verify installation of proper fuse types and ratings in fusible OCPD's.
  - 2. Electrical Tests: Perform the following tests in accordance with manufacturer's instructions:
    - a. Insulation resistance test of fused power circuit devices, insulated-case, and molded case circuit breakers, 600-ampere frame size and over at 1000 degree V d.c. for one minute from pole to pole and from each pole to ground with breaker closed and across open contacts of each phase. Insulation resistance less than 100 megohms is not acceptable.
    - b. Make insulation resistance tests of OCPD buses, components, and connecting supply, feeder, and control circuits.
    - c. Make continuity tests of circuits.
    - d. Provide full rated primary current tests conforming to NETA testing standards of all new and existing breakers 800 amperes and greater,

connected under this project. Inspect breakers and provide test report. Set breakers to previous or new settings as directed prior to test.

- e. Verify relay operation by introduction of accurately metered currents into overcurrent/ground fault/ and other circuitry at values which will enable accurate determination of the tripping or activation values.
- E. Make adjustments for final settings of adjustable-trip devices.
- F. Activate auxiliary protective devices such as ground fault or under-voltage relays, to verify operation of shunt-trip devices.
- G. Check stored-energy charging motors for proper operation of motor, mechanism, and limit switches.
- H. Check operation of electrically operated OCPDs in accordance with manufacturer's instructions.
- I. Check safety devices for operation and sequence. Make closing attempts on locked-open and opening attempts on locked-closed devices including moveable barriers and shutters.
- J. Retest: Correct deficiencies identified by tests and observations and provide retesting of OCPDs by testing organization. Verify by the system tests that specified requirements are met.

### 3.7 CLEANING:

- A. Upon completion of installation, inspect OCPD's. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

### 3.8 DEMONSTRATION:

- A. Training: Arrange and pay for the services of factory-authorized service representatives to demonstrate OCPD's and train Owner's maintenance personnel.
- B. Conduct a minimum of one day of training in operation and maintenance as specified under in the Project Closeout Section of these specifications. Include both classroom training and hands-on equipment operation and maintenance procedures.
- C. Schedule training with at least one week advance notification.

**END OF SECTION 26 28 00**

**SECTION 26 29 23 - MOTOR VARIABLE FREQUENCY DRIVES****PART 1 GENERAL****1.1 SUMMARY:**

- A. Extent of drive work is indicated by drawings and schedules.
- B. Types of drives specified in this section include the following:
  - 1. Variable Frequency Drives
- C. Installation requirements in Part 3, shown in lighter type, shall be included with installation contract.

**1.2 QUALITY ASSURANCE:**

- A. Manufacturers: Firms regularly engaged in manufacture of motor starters, of types, ratings and characteristics required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Installer's Qualifications: Firm with at least 3 years of successful installation experience on projects utilizing motor starters similar to that required for this project.

**1.3 SUBMITTALS:**

- A. Product Data: Submit manufacturer's data.
- B. Shop Drawings: Submit layout drawings showing accurately scaled equipment locations and spatial relationships to associated motors.
- C. Wiring Diagrams: Submit wiring diagrams showing connections to electrical power panels, feeders and equipment. Clearly differentiate between portions of wiring that are manufacturer-installed and portions to be field-installed.
- D. Maintenance Data: Submit O & M Manuals.

**PART 2 PRODUCTS****2.1 ACCEPTABLE MANUFACTURERS:**

- A. Manufacturers: Subject to compliance with requirements, provide motor starters of one of the following (for each type and rating of motor starter):
  - 1. Square D
  - 2. Eaton

3. ABB
4. Aquavar
5. Yaskawa
6. Others only with pre-approval by the **LPS Operations, Maintenance and Construction (OMC) Department.**

## 2.2 MOTOR VARIABLE FREQUENCY DRIVES:

- A. General: Except as otherwise indicated, provide motor drives and ancillary components which comply with manufacturer's standard materials, design and construction in accordance with published product information, and as required for complete installation.
- B. Variable Frequency Drives:
  1. Drive shall convert the constant frequency AC line voltage to a variable frequency, variable voltage AC output suitable for control of a standard NEMA design B induction motor over a 6:1 speed range.
  2. Variable Frequency Drives shall have the following features.
    - a. Controller input 460 volts, 3 phase, 60 Hz.
    - b. Controller output: 0-460 volts, 3 phase, 0-60 Hz.
    - c. Controller type: PWM or six step type, designed to minimize harmonic generated noise in the motor.
    - d. Enclosure type: NEMA 1.
    - e. AC line fused disconnect or circuit breaker.
    - f. AC line reactors in the drive cabinet for protection against line notching and surges without requirement for an input isolation transformer. Maximum total harmonic distortion shall not exceed 3 percent per IEEE 519.
    - g. Metal oxide varistors on incoming line for transient protection.
    - h. Control power and customer interface and bypass controls transformer with fused primary and 120V fused secondary.



- i. Manual speed potentiometer, HAND-OFF-AUTO switch, and 4-20 milliamp, fully isolated and suitable for grounded or ungrounded input signal.
  - j. Instantaneous overcurrent shutdown with indicator light when current exceeds 200 percent.
  - k. Inverse characteristic time-overcurrent overload protection for the motor sized in accordance with NEC requirements.
  - l. Drive shall be capable of withstanding random application of an output short circuit without damage to output devices or fuses.
  - m. Input phase loss and under-voltage protection.
  - n. Torque/current limit control which will slow the motor without tripping when the motor is subjected to an overload, or slow the acceleration ramp when accelerating a high inertia load.
  - o. Troubleshooting and diagnostic features:
    - 1) Exterior drive door-mounted devices shall include:
      - a) Percent full load motor current display.
      - b) Output frequency and/or percent-speed meter.
    - 2) LED indicators for instantaneous overload, motor overload GTO or SCR status, current limit, over-temp, phase loss, under-voltage, ground-fault and other drive functions.
    - 3) Indicator lights on PC boards to indicate correct operation (or failure). Include current limit light.
  - p. UL listed.
3. Variable frequency drives designated "with bypass" on drawings shall be equipped with a bypass device to allow for total isolation of the drive unit for service while providing for temporary operation of the motor. This shall include:
- a. A main disconnect switch in the bypass enclosure with a door interlock handle. This disconnect shall provide positive shutdown of all power to both the bypass circuitry and the VFD.
  - b. A VFD output contactor and a constant speed contactor.
  - c. A three pole motor overload relay with heaters connected to shut down the motor in both the VFD and bypass modes.

- d. A timing relay adjustable 5-30 seconds to prevent rapid switching from bypass to VFD modes.
- e. A control relay and terminal blocks which will allow two-wire, start-stop control of the motor from a single remote contact in both VFD and BYPASS (AUTO) modes of operation.
- f. A control relay and terminal blocks to allow connection of remote interlock shutdown contacts such as freezestats, smoke detectors, etc. When this interlock loop is opened, operation of the motor shall be disabled in both VFD and bypass modes.
- g. A four position oil-tite selector switch shall be provided, VFD-OFF-BYPASS(AUTO)-BYPASS(MANUAL).
- h. Indicator lights on the face of the bypass panel shall be provided as follows. Indicators shall be long life neon, LED, or transformer type incandescent types.
  - 1) "POWER ON"
  - 2) "MOTOR ON VFD"
  - 3) "MOTOR ON BYPASS CONTROL"
  - 4) "MOTOR OVERLOAD"
  - 5) "INTERLOCK SHUTDOWN"
- i. 120V control power transformer with fused secondary and primary. Bypass mode operation shall be independent of VFD control power.
- j. VFD output contactor shall be wired to allow a controlled VFD deceleration ramp to stop.
- k. Panel shall be arranged to allow power-off maintenance of the VFD while motor is operating on bypass. Bypass circuitry in the same compartment as the VFD will not be allowed.
- l. Drive to be constructed so that all electrical components are accessible when drive is in operation.
- m. Provide individual adjustment settings for entry slope (minimum and maximum) speed points when drive is in AUTO. All settings to be adjustable over 50 percent of the speed range. Minimum/maximum speed points to be effective in HAND and AUTO modes.
- n. Auto restart of the VFD after incoming power or drive fault.

- o. When shown with by-pass, auto by-pass after 3rd fault within 15 minutes.
- p. Drives must be designed for the available line fault current.
- q. Drive to include one set of form C relay contacts that are energized when drive fault occurs.

**PART 3 - EXECUTION****3.1 INSTALLATION OF MOTOR VARIABLE FREQUENCY DRIVES:**

- A. Install motor drives as indicated, in accordance with equipment manufacturer's written instructions and with recognized industry practices; complying with applicable requirements of NEC, UL and NEMA standards, to insure that products fulfill requirements.
- B. Coordinate with other work including motor and electrical wiring/cabling work, as necessary to interface installation with other work.
- C. Tests:
  - 1. Before shipment, each variable frequency drive shall be completely adjusted, operationally tested and given an extended burn-in at maximum rated enclosure temperature while running a loaded motor.
  - 2. The manufacturer shall provide a factory trained field service engineer for start-up coordination. Allow for two independent trips to the site. The first time will be for a thorough check of units and running at manual mode. The second time will be for testing and operating units in automatic and manual modes.
  - 3. After successful completion of start-up and operation of all drives for a minimum of 72 hours, the manufacturer's field service engineer shall also schedule and instruct a demonstration, training and maintenance course. This training is to take place at the jobsite and is directed to the Owner's OMC Department personnel for a minimum of eight hours. Schedule of this training shall be coordinated with the Owner field representative. Provide the Owner's field representative with three (3) sets of an updated wiring diagram and manual of maintenance and operation at least one (1) week in advance of schedule date for distribution to training participants.
  - 4. Document measured THD from 0-100 percent load and submit to verify THD is below specified level.
- D. Interlock With Controls:
  - 1. Provide a N.O. auxiliary contact to signal control that the drive is in operation.

2. Provide, internal to the drive, start/stop control circuit terminal connections to insert a dry contact from control to initiate the start/stop on automatic mode.
3. Drive shall be capable of interlocking with control equipment so that equipment can be regulated from 0-100 percent speed.

**E. Installation:**

1. Anchor free-standing units to floor slab or housekeeping pad with 1/2" minimum diameter anchor bolts. Bolts and washers shall be sufficient to resist shear and uplift produced by force equal to one-half of the equipment mass applied horizontally at center of gravity.
2. For wall mounted units, provide all necessary blocking, channels and other hardware for securing to walls, or other parts of building structure.

**END OF SECTION 26 29 23**

**SECTION 26 35 33 – POWER FILTERS AND CONDITIONERS**

## PART 1 - GENERAL

## 1.1 SUMMARY:

- A. Work in this section is restricted to specific products of specific manufacturers that have been previously approved by Littleton Public Schools.
  - 1. Current Technologies
  - 2. Liebert
  
- B. Coordination
  - 1. Section 26 05 26 – Ground Fault Protection Systems
  - 2. Section 26 05 53 – Electrical Identification
  - 3. Section 26 24 13 – Switchboards
  - 4. Section 26 24 16 – Panelboards
  
- C. References
  - 1. In the absence of other information, the following standards apply:
    - a. ANSI/IEEE compliance; Comply with ANSI/IEEE C62.1, C62.41 and C62.45.
    - b. NEC as applicable to construction and Article 280 for installation.

## 1.2 QUALITY ASSURANCE:

- A. Manufacturer Qualifications:
  - 1. Regularly engaged in the manufacture of power filter and conditioner product for category C3 (ANSI/IEEE C62.41)
  - 2. Products have been in satisfactory service for not less than ten years.

## 1.3 SUBMITTALS:

- A. Product Data: Required for all materials provided.
  
- B. Shop Drawing: Required for all assemblies installed.
  
- C. Design Data, Test Reports, Certificates, Manufacturer Instructions, Manufacturer Field Reports:
  - 1. Manufacturer's system specifications
  - 2. Latest edition of the UL 1449 surge suppression rating Category C3 for the Filter.
  
- D. Closeout:
  - 1. Submittals listed above, updated to record status.

2. Maintenance and Operating manuals

1.4 WARRANTY:

- A. System shall be warranted for five (5) years from date of acceptance by Owner.
- B. Label equipment on inside of door with length of warranty from date of acceptance.
- C. Local service support shall be provided for system such that upon failure, a replacement shall be available within twenty-four hours.

1.5 SYSTEM DESCRIPTION:

- A. Mechanical and electrical requirements suitable for application in category C3 environments as described in ANSI/IEEE C62.41.
- B. System must not affect the performance of the frequency corrected slave clock system.

1.6 EXECUTION:

- A. Conductors are to be as straight and short as practically possible; not to exceed 10 feet in length.
- B. Install an appropriately-sized manual safety/disconnect switch or circuit breaker before and in line with the system, capable of electrically isolating the system from the electrical service for repair without interrupting service to the building.
- C. Units must be downstream of main distribution center (MDC) disconnect.
- D. System shall be self-diagnostic, with panel lamp to show status of system and its functions.

**END OF SECTION 26 35 33**

**SECTION 26 36 23 - TRANSFER SWITCHES****PART 1 - GENERAL****1.1 SUMMARY:**

- A. This Section includes transfer switches rated 600 V and less. It includes the following items:
  - 1. Automatic transfer switch (ATS).
  - 2. Bypass/isolation switch (BP/IS).
  - 3. Nonautomatic transfer switch (NATS).
  - 4. Double throw disconnect switch.
  - 5. Remote annunciation and control system.

**1.2 SUBMITTALS:**

- A. Product data and shop drawings for each transfer switch, including dimensioned plans, sections, and elevations showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and materials lists.
- B. Wiring diagrams, elementary or schematic, differentiating between manufacturer-installed and field-installed wiring.
- C. Single-line diagrams of transfer switch units showing connections between automatic transfer switch, bypass/isolation switch, power source, and load, plus interlocking provisions.
- D. Operation and maintenance data for each type of product. Include all features and operating sequences, both automatic and manual. List all factory settings of relays and provide relay setting and calibration instructions.
- E. Manufacturer's certificate of compliance to the referenced standards and tested short-circuit closing and withstand ratings applicable to the protective devices and current ratings used.

**1.3 QUALITY ASSURANCE:**

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of electrical power transfer switches, of types, ratings, and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

- B. Installer's Qualifications: Firm with at least 3 years of successful installation experience on projects utilizing electrical power transfer switches similar to that required for this project.
  - C. Emergency Service: Manufacturer with a service center capable of providing emergency maintenance and repairs at the Project site with an 8-hour maximum response time.
  - D. Comply with NFPA 110, "Standard for Emergency and Standby Power Systems."
  - E. Comply with NEMA Standard ICS-2-447-AC Automatic Transfer Switches.
  - F. UL Listing and Labeling: Items furnished under this Section shall be listed and labeled by UL for emergency service under UL Standard 1008.
  - G. National Recognized Testing Laboratory Listing (NRTL) and Labeling: Items furnished under this Section shall be listed and labeled by a NRTL for emergency service under UL Standard 1008.
    - 1. Terms "Listed" and "Labeled": As defined in the "National Electrical Code," Article 100.
    - 2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.
  - H. Single-Source Responsibility: Obtain ATSS, BP/ISs, remote annunciators, and remote annunciator and control panels from a single manufacturer that assumes responsibility for all system components furnished.
  - I. Source Quality Control: Factory test components, assembled switches, and associated equipment to ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for conformance with specified requirements. Perform dielectric strength test conforming to NEMA ICS 1.
- 1.4 DELIVERY, STORAGE AND HANDLING:
- A. Deliver transfer switches and associated devices in factory-fabricated type containers or wrappings, which properly protect equipment from damage.
  - B. Store transfer switches and associated devices in original packaging, and protect from weather and construction traffic. Wherever possible, store indoors; where necessary to store outdoors, store above grade and enclose with watertight wrapping.
  - C. Handle transfer switches and associated devices carefully to prevent physical damage to equipment. Do not install damaged equipment; remove from site and replace damaged equipment with new equipment.



**PART 2 - PRODUCTS****2.1 MANUFACTURERS:**

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
  - 1. ASCO
  - 2. Cummins/Onan (When associated with Onan generator only)
  - 3. General Electric
  - 4. Automatic Switch Company. (ASCO)
  - 5. Generac

**2.2 TRANSFER SWITCH PRODUCTS, GENERAL:**

- A. Number of Poles and Current and Voltage Ratings: As indicated
  - 1. Units smaller than 400 amperes shall not have different current ratings for different classes or mixtures of loads, including 100 percent tungsten filament lamp or 100 percent inductive load.
  - 2. Units 400 amperes and larger shall have current ratings that apply to mixtures of loads including 30-percent-maximum tungsten filament lamp load.
  - 3. The current rating shall be a continuous rating when the switch is installed in an unventilated enclosure and shall comply with NEMA temperature rise standards.
- B. Tested Fault-Current Ratings: Closing and withstand ratings shall exceed the indicated available rms symmetrical fault current at the equipment terminals based on testing according to UL Standard 1008, conducted at full-rated system voltage and 20 percent power factor. Rate each product for withstand duration time as follows when tested for rated short-circuit current correlated with the actual type of circuit protective device indicated for transfer switches for this Project.
  - 1. 150 Amperes or Smaller: 1.5 closing and withstand duration cycles.
  - 2. Larger than 150 Amperes: 3 closing and withstand duration cycles.
  - 3. Power Circuit Breakers: 10 closing and withstand duration cycles.
  - 4. Current-Limiting Fuses: 0.5 (nominal) closing and withstand duration cycles.

- C. Annunciation and Control Interface Components: Provide devices at transfer switches for communicating with remote annunciators or annunciator/control panels which have communications capability matched with the remote device.
- D. Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 degrees C. to 70 degrees C.
- E. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage surge withstand capability requirements when tested according to ANSI C37.90.1, IEEE Guide for Surge Withstand Capability (SWC) Tests. Components meet or exceed voltage impulse withstand test of NEMA ICS 1.
- F. Neutral Terminal: Where 2- or 3-pole switches are indicated, provide fully rated, solid, unswitched neutral terminal.
- G. Four-Pole Switches: Where 4-pole switches are indicated, provide full-capacity and neutral switching.
- H. Enclosures: Provide a general-purpose NEMA 1 enclosure, conforming to UL Standard 508, "Electrical Industrial Control Equipment," except as otherwise indicated.
- I. Heater: Provide a heater within enclosure of units exposed to outdoor temperature and humidity conditions. Connect thermostat within enclosure to control heater.
- J. Factory Wiring: Train and bundle factory wiring and identify consistently with shop drawings, either by color code or by numbered or lettered wire and cable tape markers at terminations.
  - 1. Designated terminals accommodate field wiring.
  - 2. Power Terminal Arrangement and Field Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
  - 3. Terminals: Pressure-type, suitable for copper or aluminum conductors of sizes indicated.
  - 4. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
- K. Electrical Operation: Where indicated, accomplish by a non-fused, momentarily energized solenoid or electric motor-operated mechanism, mechanically and electrically interlocked in both directions. Switches using components of molded-case circuit breakers or contactors not designed for continuous-duty, repetitive switching between active power sources are not acceptable.

- L. Switch Action: The switch contacts shall be mechanically held in both directions for double-throw switches.
- M. Switch Contacts: Use silver composition for switching load current. Units rated 225 amperes and more shall have separate arcing contacts.
- N. Overcurrent devices are not part of switch products.
- O. Transfer switch shall use copper bus throughout.
- P. Control power for transfer switches shall operate from either source as available and shall include a connection terminal for a third separate source of power. Control, indication alarms, etc., shall operate from any of these sources automatically.
- Q. Provide two-hole compression lugs on all incoming and load side phase, neutral, and ground connectors.

### 2.3 AUTOMATIC TRANSFER SWITCHES (ATSS):

- A. Comply with Level 1 equipment according to NFPA 110, "Standard for Emergency and Standby Power Systems."
- B. Comply with NFPA 20, "Standard for the Installation of Centrifugal Fire Pumps," for ATS's serving fire pumps.
- C. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning [except for neutral position, to enable programmed transition.]
- D. Manual Switch Operation: The switch shall have provision for manual operation under load with the door closed with either or both sources energized. Transfer time shall be the same as for electrical operation. Control circuit shall automatically disconnect from electrical operator during manual operation.
- E. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts shall operate in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.
- F. Digital Communications Interface: Provide full-duplex RS - 485/422/232 type, matched to capability of remote annunciator and control panel.
- G. In-Phase Monitor: Include factory-installed and factory-wired internal in-phase monitor relay. The relay controls transfer so it occurs when the 2 sources are synchronized in phase. the relay compares phase relationship and frequency difference between the normal and emergency sources and initiates transfer when both sources are

within +5 electrical degrees and +5 percent voltage difference, and then only if the transfer can be of nominal frequency and 70 percent or more of nominal voltage.

OR

Programmed Transition with Motor Control: Provide factory-installed and factory-wired internal motor control undervoltage and timing relays. Relays shall control designated starters to de-energize motors prior to transfer and re-energize them selectively at adjustable time intervals after transfer. Control connection to motor starters shall be through wiring external to the ATS. Time delay for individual motor loads shall be adjustable between 1 and 60 seconds and settings are as indicated. Relay contacts shall be rated for actual motor-control circuit inrush and seal currents, or for pilot duty as indicated.

OR

Programmed Transition: Switch Operator shall have a programmed neutral position arranged to provide a midpoint between the 2 working switch positions with an intentional, controlled, timed pause during transfer at the midpoint. The midpoint pause shall be adjustable from 0 to 60 seconds minimum, and factory set at 5 seconds, except as indicated. Time delay shall occur for both transfer directions.

#### 2.4 AUTOMATIC TRANSFER SWITCH FEATURES:

- A. Provide for normal source voltage sensing of each phase of normal source. Pick-up voltage shall be adjustable from 85 percent to 100 percent nominal, and drop-out voltage is adjustable from 75 percent to 98 percent pick-up value. Factory set for pick-up at 95 percent and drop-out at 85 percent.
- B. Provide for emergency source voltage sensing to prevent premature transfer. Voltage pick-up shall be adjustable from 85 percent to 100 percent of nominal. Factory set to pick-up at 90 percent. Pick-up frequency shall be adjustable from 90 percent to 100 percent of nominal and factory set to pick-up at 95/98 percent.
- C. Provide a transfer switch signal time delay to override normal source voltage-sensing, delay transfer signal and engine start signal. Delay shall be adjustable from 0 to 6 seconds, and factory set at 1/5 sec.
- D. Provide a transfer to emergency time delay to delay transfer switch changeover after transfer signal. Delay shall be adjustable from 0 to 5 minutes and factory set at 0 minutes.
- E. Provide a retransfer time delay to provide for automatic defeat of the delay upon loss of voltage or sustained under-voltage of the emergency source, provided the normal supply has been restored. Delay shall be adjustable from 0 to 30/60 minutes and factory set at 15 minutes.

- F. Provide an engine shut-down time delay adjustable from 0 to 5/15 minutes and factory set at 5 minutes.
- G. Provide a momentary type test switch to simulate normal source failure.
- H. Provide switch position pilot lights to indicate source to which the load is connected.
- I. Provide source available indicating lights to supervise sources via the 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."
- J. Provide a transfer override switch to override automatic retransfer control so the ATS will remain connected to the emergency power source regardless of the condition of the normal source. Provide a pilot light to indicate the override status.
- K. Provide engine starting contacts, one isolated normally closed and one isolated normally open. Contacts shall be gold flashed or gold plated and rated 10 amperes at 32 V d.c. minimum.
- L. Provide two normally open and two normally closed spare SPDT contacts for each switch position, rated 10 amps at 240 VAC.

AND/OR

- M. Provide auxiliary emergency position and normal position relays. Each relay shall have two normally open and two normally closed SPDT contacts for each switch position, rated 10 amps at 120 VAC.
- N. Provide an elevator pre-signal relay (when interface with elevator is within scope) to signal the elevator equipment that re-transfer to normal source is imminent and to shutdown SCR controller, then startup after re-transfer.
- O. Provide a solid-state programmable engine-generator exerciser time switch to start engine-generator set and transfer load to it from normal source for a preset time, then retransfer loads to normal source and shut down engine after a preset cool-down period. The exercise cycle shall be initiated at preset intervals adjustable from 7 to 30 days. Running periods shall be adjustable from 10 to 30 minutes and factory-set for 7 days and 20 minutes respectively. Exerciser features include:

- P. Exerciser transfer selector switch which permits selection between exercise with and without load transfer.
  - 1. Push button programming controls with digital display of settings.
  - 2. Integral battery operation of time switch when normal control power is not available.

#### 2.5 BYPASS/ISOLATION SWITCH FEATURES:

- A. Comply with requirements for Level 1 equipment per NFPA 110, Standard for Emergency and Standby Power Systems.
- B. Description: Manual type, arranged to select and connect either source of power directly to the load, isolating the transfer switch from the load and from both power sources. Include the following features:
  - 1. Means to lock the BP/IS in the position that isolates the transfer switch, with an arrangement that permits complete electrical testing of the transfer switch while isolated. While isolated, interlocks shall prevent transfer switch operation except for testing or maintenance.
  - 2. Draw-out arrangement for the transfer switch: Provide physical separation from live parts for testing and maintenance operations.
  - 3. Current, voltage, closing, and short-circuit withstand rating shall be equal to or greater, than that of the associated ATS, with the same phase arrangement and number of poles.
  - 4. Contact temperatures of BP/IS shall not exceed those of ATS contacts when they are carrying rated load.
  - 5. Construct so that load bypass and transfer switch isolation can be performed by 1 person in no more than 2 operations in 15 seconds or less.
  - 6. Provide a Manufacturer's standard legend for control labels and instruction signs which give detailed operating instructions.
  - 7. Fabricate BP/IS to allow convenient removal of major components from the front without removal of other parts or main power conductors.
- C. Interconnect BP/IS and ATS with copper bus bars plated at connection points and braced for the indicated available short circuit current.

#### 2.6 NONAUTOMATIC TRANSFER SWITCHES FEATURES:

- A. Comply with applicable requirements of NFPA 100, "Standard for Emergency and Standby Power Systems."
- B. Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternate Source." Provide a removable manual handle. Provide quick-make, quick-break switching action. The switch shall be capable of electrically or manually transferring the load in either direction, with one or both sources energized. The control circuit shall disconnect from the electrical operator during manual operation. Control shall ensure switch will not transfer to a dead source.
- C. Double-Throw Switching Arrangement: Incapable of pauses or intermediate position stops during switching sequence unless otherwise specified.
- D. NATS Accessories:
  - 1. Provide pilot lights to indicate source to which the load is connected.
  - 2. Provide source availability indicating lights which supervise sources via the transfer switch normal and alternate source sensing circuits, respectively.
    - a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    - b. Emergency Power Supervision: Red light with nameplate engraved "Alternate Source Available."
  - 3. Provide two sets of spare normally closed and normally open SPDT contacts for each switch position, rated 10 amperes at 240 VAC.

#### 2.7 DOUBLE-THROW DISCONNECT SWITCH (DTDS):

- A. Standards:
  - 1. Comply with UL 98 - Enclosed and Dead Front Switches, NEMA Enclosed Switch Standard KSI-1990.
  - 2. Heavy-duty rating.
- B. Description: Manually operated load break switch, double throw with intermediate OFF position, 2/3-pole with solid neutral terminal, service entrance rated, non-fusible.
- C. Accessories:
  - 1. Provide padlock provision for both "OFF" and "ON" positions.
  - 2. Provide dual cover interlock with keyed defeat mechanism.

3. Label switch positions
  - a. "UTILITY"
  - b. "OFF"
4. Provide electrical interlocks with two normally open and two normally closed contacts in "ON" position.

#### 2.8 REMOTE ANNUNCIATION AND CONTROL SYSTEM DESCRIPTION:

- A. Provide a remote annunciation and control panel which shall provide the functions listed below at indicated transfer switches.
  1. Sources-available indication (as defined by actual pick-up and drop-out settings of transfer switch controls).
  2. Switch position indication.
  3. Switch in test mode indication.
  4. Failure of digital communications link indication.
  5. Key switch or user code access to control functions of panel.
  6. Control of switch test initiation.
  7. Control of switch operation in either direction.
  8. Control of bypass of time delay for transfer to normal source.
  9. Malfunction of the annunciator unit or communication link shall not affect functions of the ATS. In the event of a failure of the communication link, the ATS automatically reverts to stand-alone, self-contained operation. No ATS sensing, controlling, or operating function depends on the remote panel for proper operation.
- B. Remote Annunciator and Control Panel Features:
  1. Description: Solid-state control and indicating panel. Group controls and indicating lights for each transfer switch together. Label each group indicating the transfer switch it controls, the location of that switch, and the load it serves.
  2. Provide digital communications matched to that of the transfer switches to be supervised.



3. Provide flush/surface mounted modular, steel cabinet except as indicated.

## 2.9 FINISHES

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

## PART 3 - EXECUTION

### 3.1 EXAMINATION:

- A. Examine areas and conditions under which transfer switches are to be installed and notify Contractor in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to the Installer.

### 3.2 INSTALLATION OF AUTOMATIC TRANSFER SWITCHES:

- A. Install transfer switches, including associated control devices as indicated, in accordance with equipment manufacturer's written instructions, and with recognized industry practices, to ensure that transfer switches comply with requirements. Comply with applicable requirements of NEC and NFPA pertaining to wiring practices and installation of electrical power transfer switches.
- B. Coordinate with other electrical work, including raceways, and electrical boxes and fittings, as necessary to interface installation of transfer switch work with other work.
- C. Tighten factory-made connections, including connectors, terminals, bus joints, mountings, and grounding. Tighten field-connected connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque values. When manufacturer's torque requirements are not indicated, tighten connectors and terminals to comply with torque values specified in UL Standards 486A and 486B.

### 3.3 WIRING TO REMOTE COMPONENTS:

- A. Match the type and number of cables and conductors to the control and communications requirements of the transfer switches used. Increase raceway sizes at no additional cost to the Owner if necessary to accommodate required wiring.

### 3.4 GROUNDING:

- A. Make equipment grounding connections for transfer switch units as indicated and as required by the NEC.

### 3.5 FIELD QUALITY CONTROL:

- A. Manufacturer's Field Services: Provide services of a factory-authorized service representative to supervise field tests.
- B. Preliminary Tests: Perform electrical tests as recommended by the manufacturer and as follows:
  - 1. Measure phase-to-phase and phase-to-ground insulation resistance levels with insulation resistance tester, including external annunciator and control circuits. Use test voltages and procedure recommended by the manufacturer. Meet manufacturer's specified minimum resistance.
  - 2. Check for electrical continuity of circuits and for short circuits.
- C. Field Tests: Give one week advance notice of the tests and perform tests in presence of Owner's representative.
- D. Coordinate tests with tests of generator plant and run them concurrently.
- E. Tests: As recommended by the manufacturer and as follows:
  - 1. Contact Resistance Test: Measure resistance of power contacts for ATSS, NATSS, and BP/ISs. Resolve values in excess of 500 micro-ohms and differences between adjacent poles exceeding 50 percent.
  - 2. Ground Fault Tests: Coordinate with testing specified in Section 26 28 00 on Overcurrent Protective Devices to ensure sensors are properly selected and located to optimize ground-fault protection where power is being delivered from either source.
    - a. Verify grounding points and sensor ratings and locations.
    - b. Apply simulated fault current at the sensors and observe reaction of circuit interrupting devices.
  - 3. Operational Tests: Demonstrate interlock, sequence, and operational function for each switch at least 3 times.
    - a. Simulate power failures of normal source to ATSS and of emergency source with normal source available.
    - b. Simulate low phase-to-ground voltage for each phase of normal source of ATSS.
    - c. Verify time-delay settings and pick-up and drop-out voltages.

- d. Verify all control and relay devices operate properly in each sequence.
  
- 4. Test Failures: Correct deficiencies identified by tests and prepare for retest. Verify that equipment meets the specified requirements.
  
- 5. Reports: Maintain a written record of observations and tests. Report defective materials and workmanship and retest corrected items. Record adjustable relay settings and measure insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

**3.6 DEMONSTRATION:**

- A. Training: Furnish the services of a factory-authorized service representative to instruct Owner's personnel in the operation, maintenance, and adjustment of transfer switches and related equipment. Provide a minimum of four (4) hours of instruction scheduled seven (7) days in advance.
  
- B. Post step-by-step procedures for each switch provided.

**END OF SECTION 26 36 23**

**SECTION 26 43 13 - TRANSIENT VOLTAGE SURGE SUPPRESSION (TVSS)**

**PART 1 - GENERAL**

**1.1 DESCRIPTION OF WORK:**

- A. Extent of TVSS work is indicated by drawings and by requirements of this section.
- B. Types of TVSS equipment required for this project include the following:
  - 1. Category b or c for distribution panelboards.

**1.2 QUALITY ASSURANCE:**

- A. Manufacturers: firms regularly engaged in manufacture of TVSS equipment of types, ratings, capacities and characteristics required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Installer's qualifications: firm with at least 5 years of successful installation experience with projects utilizing rectifier and inverter work similar to that required for this project.
- C. The specified system shall be factory-tested before shipment. Testing of each system shall include but shall not be limited to quality control checks, "hi-pot" tests at twice rated voltage plus 1000 volts per UL requirements, IEEE c62.41 category b surge tests, UL ground leakage test, and operation and calibration tests.

- D. The project shall be life cycle tested following suggested wait times as defined by ANSI/IEEE C62.45 (1987) and shall be capable of surviving 1000 sequential category C surges of 10,000 amps without failure.
- E. The system shall be UL listed as a complete system under UL 1449 (rev 7/2/87) standard for transient voltage surge suppressors (TVSS) and the rating shall be permanently affixed to the TVSS.

### 1.3 SUBMITTALS:

- A. Product data: submit manufacturer's data on TVSS equipment.
- B. Shop drawings: submit drawings of TVSS equipment indicating unit dimensions, weights, component and connection locations, mounting provisions, connection details and wiring diagrams.
- C. Operation and maintenance manual: the manufacturer shall provide an operation and maintenance manual containing installation, start-up, and operating instructions and a list of recommended spare parts for each system specified.
- D. Test reports: documentation of specified system's UL 1449 listing and clamping voltage ratings shall be provided. This shall include computer generated graphs and oscillograms. Tests shall follow procedures outlined in ANSI/IEEE C62.45 (1987) for installation category and applicable protection modes of TVSS.

### 1.4 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver TVSS equipment and accessories individually packaged in factory-fabricated containers. Mount units on shipping skids.
- B. Handle equipment carefully to prevent internal component damage, impact, breakage, denting, and scoring enclosure finishes. Do not install damaged equipment; replace and return damaged units to equipment manufacturer.

- C. Store equipment in clean dry space. Protect units from dirt, fumes, water, construction debris and traffic.

1.5 WARRANTY:

- A. The manufacturer shall provide a full five year warranty from date of shipment against any part failure when installed in compliance with manufacturer's written instructions, UL listing requirements, and any applicable national or local electrical codes.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

- A. Manufacturer: Subject to compliance with requirements, provide TVSS products of the following:
  - 1. GE/Liebert
  - 2. Square D
  - 3. Current Technology

2.2 SYSTEM DESCRIPTION:

A. Environmental Requirements:

- 1. Storage Temperature: -67 degrees F to +185 degrees F (-55 degrees C to +85 degrees C).

2. Operating Temperature: -40 degrees F to +122 degrees F (-40 degrees C to +50 degrees C).
3. Relative Humidity: Operation shall be reliable in an environment with 5 percent to 95 percent non-condensing relative humidity.
4. Audible Noise: The audible noise level of the specified system shall be less than 45 dBA at 5 feet.
5. Operating Altitude: The system shall be capable of operating up to an altitude of 12,000 feet above sea level.
6. Magnetic Fields: Unit shall not generate appreciable magnetic field, and shall be capable of use directly in computer rooms in any location without danger to data storage systems or devices.

#### B. Electrical Requirements:

1. System Operation Voltage: The nominal system operating voltage shall be 277/480 V 3 WYE, 4-wire plus ground, or as indicated on drawings.
2. Maximum Continuous Operating Voltage (MCOV): The TVSS maximum continuous operating voltage shall not be less than 115 percent of the nominal system operating voltage to ensure the ability of the system to withstand temporary RMS overvoltage conditions. Each system shall be factory tested at the MCOV for at least one (1) hour.
3. Operating Frequency: The operating frequency range of the system shall be at least 47 to 63 Hertz.
4. Protection Modes: The TVSS shall provide protection as follows:
  - a. Line to line (Delta Configured System)
  - b. Line to ground
  - c. Neutral to ground (Wye Configured System)
  - d. Line to neutral (Wye Configured System)
5. Performance Ratings: Provide TVSS surge current capacity based on an 1.2x50 microsecond 20KV open circuit voltage, 8x20 microsecond short circuit current Category C3 Bi-wave per ANSI/IEEE C62.41-1991 and

C62.45-1995 standards as follows: (A balanced surge current capacity shall also be applied Neutral to Ground and Line to Neutral where neutrals are present in the system).

Service Entrance

Per Phase	400 kAmps
Line to Neutral	200 kAmps
Line to Ground	200 kAmps
Line to Line	200 kAmps

Subdistribution

Per Phase	300 kAmps
Line to Neutral	150 kAmps
Line to Ground	150 kAmps
Line to Line	150 kAmps

Panelboards

Per Phase	120 kAmps
Line to Neutral	60 kAmps
Line to Ground	60 kAmps
Line to Line	60 kAmps

**2.3 TVSS EQUIPMENT:**

- A. Components: The system shall be a symmetrically balanced, metal oxide varistor (MOV) array system, constructed using surge current diversion modules. Each module shall be capable of withstanding over 1000 pulses of the 10 kAmps IEEE



C62.41 Category C surge current without degradation of clamping voltage. The module shall consist of multiple gap-less metal oxide varistors, with each MOV individually fused. The modules shall be designed and constructed in a manner which ensures reasonable MOV surge current sharing. No gas tubes or silicon avalanche diodes shall be used. The status of each varistor shall be monitored and green LED shall be illuminated if the module is in full working order. When module performance is degraded, such as if one or more fuses or varistors have failed, the LED shall indicate a failed module.

- B. High Frequency Tracking Filter: The unit shall include a UL 1238 high-frequency extended range tracking filter. The filter shall provide for high frequency transient filtering of up to 5 dB attenuation (per MIL-STD E220A) for the band width extending from 100 KHZ to 100 MHZ. This filtering must remove low level surges and sharp wavefronts associated with fast rise-time transients, thus eliminating disturbances which may lead to "system upset".
- C. Connections: Terminals shall be provided for all of the necessary power and ground connections. The terminals shall accommodate wire sizes of #14 to #2/0 AWG for two conductors per required connection. The units shall use standard parallel wiring techniques.
- D. Internal Connections: All surge current diversion module intra-unit connections shall be by way of low impedance busbars or wiring. Surge current diversion modules shall use low impedance connections. All module mounting hardware and power wiring shall be captive or remain in place when a module is removed or replaced.
- E. Enclosure: The specified system shall be provided in a heavy duty NEMA 12 dusttight, and driptight enclosure with no ventilation openings. The cover of the enclosure shall be hinged and require a tool for access to internal components. A drawing pocket shall be provided inside the door for storage of unit drawings and installation/operation manual. Indication of surge current module status shall be visible without opening the door.
- F. Integral Test Point: The unit shall incorporate an integral test point allowing easy off-line diagnostic testing which verifies operational integrity of the unit's suppression/filter system.

## 2.4 ACCESSORIES:

- A. LED indicators shall be provided on the hinged front cover to redundantly indicate unit module status. Additionally, a Form C (one N.O. and one N.C.) summary alarm contact rated for at least 120 VAC and 1 ampere shall be provided for remote annunciation of unit status. The summary alarm contact shall change state if any one or more of the surge current diversion modules has failed.
  
- B. Integral Fused Disconnect Switch: The unit shall include an integral fused and safety interlocked disconnect switch located in the unit enclosure with an externally mounted manual operator. The switch shall disconnect all ungrounded circuit conductors from the distribution system to enable testing and maintenance without interruption of power to the facility's distribution system. The switch shall be rated for 600 VAC. Each current-carrying, ungrounded circuit conductor connected to the facility's distribution system shall be individually fused with 200,000 AIC rated fuses in order to provide maximum fault current protection. The unit shall be UL 1449 Listed with the integral fused disconnect switch. UL 1449 Suppression Rating for this configuration shall also be provided. (1.4.6 Performance Ratings.) Specify Integral Fused Disconnect Switch by adding a "DF" suffix to the model number.
  
- C. Diagnostic Test Set: A Diagnostic Test Set shall be provided which verifies the operational integrity of the unit's suppression system. The Diagnostic Test Set shall be self-contained and portable, and shall provide complete assurance of the unit's installation and capability without stressing the suppression system or posing detriment to continued operation. Specify Diagnostic Test Set as model number DTS 1000.

## PART 3 - EXECUTION

### 3.1 INSPECTION:

- A. Installer must examine areas and conditions under which TVSS equipment is to be installed, and notify contractor in writing of those conditions detrimental to

proper completion of work. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to installer.

### 3.2 INSTALLATION OF TVSS EQUIPMENT:

- A. Install TVSS as indicated, in accordance with manufacturer's written instructions and with recognized industry practices to ensure that TVSS installation complies with requirements of NEMA standards and NEC, and applicable portions of NECA's "standard of installation," for installation of units.
- B. Coordinate with other work, including electrical wiring work, as necessary to interface installation of TVSS with other work.
- C. Install electrical protective devices, if any, for each TVSS unit.
- D. The installing contractor shall install the parallel TVSS with short and straight conductors as practically as possible. The contractor shall twist the TVSS input conductors together to reduce input conductor inductance.
- E. Field installation: the unit shall be installed as close as practical to the facility's wiring system in accordance with applicable national/local electrical codes and the manufacturer's recommended installation instructions. Connection shall be with #2 AWG copper conductor or larger and not be any longer than necessary, avoiding unnecessary bends. Notify engineer prior to installation if unit cannot be installed within manufacturer's required distances.

### 3.3 ADJUSTING AND CLEANING:

- A. Touch-up scratched and marred surfaces of equipment to match original finishes; remove dirt and construction debris.

**3.4 FIELD QUALITY CONTROL:**

- A. Upon completion of installation of TVSS equipment and after circuitry has been energized with rated power source, verify the equipment is operating properly. Where possible, correct malfunctioning units at site; otherwise remove and replace with new units and re-verify operation.

**END OF SECTION 26 43 13**

**SECTION 26 50 00 - LIGHTING**

**PART 1 - GENERAL**

**1.1 SUMMARY:**

- A. Extent, location, and details of lighting work are indicated on drawings and in schedules.
  
- B. Types of lighting in this section include the following:
  - 1. LED
  
  - 2. Fluorescent (where matching existing, only)

**1.2 SUBMITTALS:**

- A. Product Data: Submit manufacturer's product data and installation instructions on each type of luminaire and component.
  
- B. Shop Drawings: Submit layout drawings of lighting and their spatial relationship to each other. In addition, submit shop drawings in booklet form with separate sheet for each luminaire, assembled by "luminaire type" with proposed luminaire and accessories clearly indicated on each sheet. Submit details indicating compatibility with ceiling grid system. Submit shop drawings from manufacturers detailing luminaire dimensions, weights, methods of field assembly, components, features and accessories.
  
- C. Wiring Diagrams: Submit wiring diagrams for lighting showing connections to electrical power panels, switches, dimmers, controllers and feeders. Differentiate

between portions of wiring which are manufacturer-installed and portions which are field- installed.

- D. Samples: Submit one complete operating unit for each type of custom luminaire specified.
  
- E. Maintenance Data: Submit maintenance data and parts list for each luminaire and accessory; including "trouble-shooting" maintenance guide. Include that data, product data, and shop drawings in a maintenance manual; in accordance with general requirements of the **LPS** General Conditions of the Contract.

### 1.3 QUALITY ASSURANCE:

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of lighting of sizes, types and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years.
  
- B. Installer's Qualifications: Firms with at least 3 years of successful installation experience on projects with lighting work similar to that required for this project.

### 1.4 DELIVERY, STORAGE, AND HANDLING:

- A. Deliver lighting in factory-fabricated containers or wrappings, which properly protect luminaires from damage.
  
- B. Store lighting in original packaging. Store inside well-ventilated area protected from weather, moisture, soiling, extreme temperatures and humidity, laid flat and blocked up off ground.
  
- C. Handle lighting carefully to prevent damage, breaking, and scoring of finishes. Do not install damaged units or components; replace with new.

**1.5 SEQUENCING AND SCHEDULING:**

- A. Coordinate with other work including wires/cables, electrical boxes and fittings, and raceways, to properly interface installation of lighting with other work.
- B. Sequence lighting installation with other work to minimize possibility of damage and soiling during remainder of construction.

**1.6 EXTRA MATERIALS:**

- A. Lamps : Furnish stock or replacement lamps amounting to 15%, but not less than 4 lamps in each case, of each type and size lamp used in each type luminaire.
- B. Ballasts: Furnish stock or replacement ballasts amounting to 5%, but not less than 2 of each type used in each type luminaire.
- C. Lenses: Furnish stock or replacement lenses amounting to 3%, but not less than one, of each type and size used in each type luminaire.
- D. Deliver replacement stock to Owner's storage space, as directed.

**PART 2 - PRODUCTS****2.1 MANUFACTURERS:**

- A. Luminaire Manufacturers: Subject to compliance with requirements, provide LED luminaires as listed in the luminaire schedule or elsewhere on the drawings or specification. Preferred manufacturers and products acceptable to LPS include: Lithonia, CREE and Lumark; alternative manufacturers and products acceptable to

LPS include: GE and Philips. (See detailed list in LPS Standards “Appendix - Electrical Divisions”.)

**B. Lamp Manufacturers:**

1. GE Lighting
2. Osram Sylvania
3. Philips Lighting Company

**C. Fluorescent Ballast Manufacturers:**

1. GE Ultramax or equal
2. Advance
3. All other manufacturers shall request prior approval and supply test data from an independent testing laboratory and comparison report to substantiate compliance with specifications and specified equipment.

**D. Lighting Controls: Lutron, only.**

**2.2 EQUIPMENT:**

- A. General:** Provide lighting of sizes, types and ratings indicated; complete with, but not limited to, housings, energy-efficient lamps, lamp holders, reflectors, energy efficient ballasts, starters and wiring. Ship luminaires factory-assembled, with those components required for a complete installation. Design luminaire with concealed hinges and catches, with metal parts grounded as common unit, and so constructed as to dampen ballast generated noise and as to disconnect ballast when door is opened for HQI lamps.
- B. Wiring:** Provide electrical wiring within luminaire suitable for connecting to branch circuit wiring as follows:
1. NEC Type TFN for 120 and 277 volt and shall be minimum No. 18 AWG.



## C. Lamps:

1. Fluorescent: Provide fluorescent lamp types as specified in the luminaire schedule and types compatible with luminaires. Lamps shall be low mercury type. **LPS** standard shall be Phillips 28-watt 4100°K color temperature lamps unless otherwise noted in schedules or on drawings.
2. LED: LPS standard LED lights shall be 4000-4100°K indoor and 3000-3500°K outside.

## D. Interior Fluorescent Ballasts:

1. Provide high-frequency programmed rapid start electronic ballasts for all fluorescent lamps with voltage as indicated on the plans and luminaire schedule. The ballast shall deliver normal lamp life and must be interchangeable with electromagnetic ballasts. The light output shall not vary in response to an input voltage variance of less than 10% rated voltage. Drive output shall be greater than 42 KHz with lamp flicker less than 2%. Low ballast factor and parallel-wired fluorescent fixtures, only.
2. The ballast total harmonic distortion shall be less than 10% with the number of lamps as identified per luminaire type or as indicated in the luminaire schedule.
3. The ballast shall have a crest factor of less than 1.5 and shall have transient protection which meets IEEE 587, Category A (ANSI C62.41) requirements.
4. The ballast shall have a power factor of 0.98 or higher, and shall have a ballast efficiency of 90% or higher.
5. The ballast shall be UL listed Class P and shall have a sound rating better than A.

6. The ballast electromagnetic interference and radio frequency interference shall comply with FCC CFR 47, Part 18 requirements for both conducted and radiated EMI/RFI.
  7. The ballast shall contain no PCB's.
  8. Minimum lamp starting temperature of 0 degrees F.
  9. Provide ballast with color coded integral leads per ANSI C82.11
- E. Fluorescent Dimming Ballasts: Solid state type for smooth dimming over a range from 100% to 1%, 5% or 10% light output and listed for use with the specific fluorescent dimmers or dimming system. Dimming ballasts shall be Lutron Hi-Lume for 1%, Lutron Hi-Lume compact or Tu-Wire for 5%, and Lutron Eco-10 for 10% dimming.
- F. Lighting Controls: Lutron MT system with Maestro occupancy sensing switches, PowPak relay modules with Softswitch, and wall-mounted wireless occupancy and vacancy sensors with XCT Technology.

**PART 3 - EXECUTION**

**3.1 EXAMINATION:**

- A. Examine areas and conditions under which lighting is to be installed, and substrate for supporting lighting. Notify Contractor in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

**3.2 INSTALLATION:  
LPSCM - PART 3**

- A. Install lighting at locations and heights as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC, NECA's "Standard of Installation", NEMA standards, and with recognized industry practices to ensure that lighting fulfills requirements.
  
- B. Provide luminaires and/or outlet boxes with hangers to properly support luminaire weight. Submit design of hangers, method of fastening, other than indicated or specified herein, for review by Architect/Engineer.
  - 1. Luminaires shall be positively attached to the suspended ceiling system. The attachment device shall have a capacity of 100% of the luminaire weight acting in any direction.
  
  - 2. When intermediate systems are used, No. 12 gauge hangers shall be attached to the grid members within 3" of each corner of each luminaire.
  
  - 3. When heavy-duty systems are used, supplemental hangers are not required if a 48" modular hanger pattern is followed. When cross runners are used without supplemental hangers to support luminaires, these cross runners shall provide the same carrying capacity as the main runner.
  
  - 4. Luminaires weighing less than 56 pounds shall have, in addition to the requirements above, two No. 12 gauge hangers connected from the luminaire housing to the structure above. These wires may be slack.
  
  - 5. Luminaires weighing 56 pounds or more shall be supported directly from the structure above by four No. 12 gauge hangers connected from the luminaire housing to the structure above. These wires may be slack.
  
- C. Install flush mounted luminaires properly to eliminate light leakage between frame and finished surface.

- D. Provide plaster frames for recessed luminaires installed in other than suspended grid type acoustic ceiling systems. Brace frames temporarily to prevent distortion during handling.
- E. For air supply type troffers, retain side slot closures in place for adjustment by the Balancing Contractor.
- F. Fasten luminaires securely to structural supports; and ensure that pendant luminaires are plumb and level. Provide individually mounted pendant luminaires longer than 2 feet with twin stem hangers. Provide stem hanger with ball aligners and provisions for minimum one inch vertical adjustment. Mount continuous rows of luminaires with an additional stem hanger greater than number of luminaires in the row.
  - 1. Pendant hung luminaires shall be supported directly from the structure above with No. 9 gauge wire or approved alternate support without using the ceiling suspension system for direct support.
- G. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque values for equipment connectors. Where manufacturer's torque requirements are not indicated, tighten connectors and terminals to comply with torque values specified in UL 486A and B.
- H. Support surface mounted luminaires greater than 2 feet in length at a point in addition to the outlet box stud.
- I. Set units plumb, square, level and secure according to manufacturer's written instructions and shop drawings. Refer to Section 26 56 13 "Poles and Standards" for other requirements.

### 3.3 FIELD QUALITY CONTROL:

- A. Replace defective and burned out lamps for a period of one year following the Date of Final Completion.

OR

- B. At Date of Final Completion, replace lamps in lighting which are observed to be noticeably dimmed after Contractor's use and testing, as judged by Architect/Engineer.

- 1. Refer to the General Conditions of the Contract and other Division 26 sections for the replacement/ restoration of lamps in lighting where used for temporary lighting prior to Date of Final Completion.

**3.4 ADJUSTING AND CLEANING:**

- A. Clean lighting of dirt and construction debris upon completion of installation. Clean fingerprints and smudges from lenses and reflectors.
- B. Protect installed luminaires from damage during remainder of construction period.
- C. Adjust aim-able luminaires to provide required light intensities.

**3.5 GROUNDING:**

- A. Provide equipment grounding connections for lighting as indicated. Tighten connections to comply with torque values specified in UL Std 486A to assure permanent and effective grounds.
- B. Ground luminaires according to Section 26 05 26 "Ground Fault Protection Systems" and Section 26 56 13 "Poles and Standards."

- A. The Contractor shall guarantee all equipment including ballasts, lamps, luminaires, wiring, etc. free from inherent mechanical and electrical defects. Warranty period shall be from date of acceptance as set forth in the General Conditions with periods as follows:
1. Lamps - See Paragraph 3.3
  2. Luminaires, wiring, etc. - 1 year
  3. Ballasts - The manufacturer shall provide a full five-year warranty beginning at time of Final Completion. The manufacturer shall replace any and all failed ballasts within 48 hours of notification. The manufacturer shall provide the labor for warranty replacements.

**3.7 DEMONSTRATION:**

- A. Upon completion of installation of lighting and after building circuitry has been energized, apply electrical energy to demonstrate capability and compliance with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.

**END OF SECTION 26 50 00**

**SECTION 26 52 00 - EMERGENCY LIGHTING****PART 1 - GENERAL****1.1 SUMMARY:**

- A. Types of emergency luminaires in this section include the following:
  - 1. Unitized battery powered units
  - 2. Exit lights
  - 3. Emergency LED luminaire power supply.
  - 4. Emergency fluorescent lamp power supply (where matching existing, only).

**1.2 QUALITY ASSURANCE:**

- A. **Manufacturer's Qualifications:** Firms regularly engaged in manufacture of emergency luminaires and equipment of types and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. **Installer's Qualifications:** Firm with at least 3 years of successful installation experience on projects with emergency lighting work similar to that required for project.

**1.3 SUBMITTALS:**

- A. **Product Data:** Submit manufacturer's technical product data on emergency lighting.
- B. **Shop Drawings:** Submit shop drawings in booklet form with separate sheet for each luminaire, assembled in luminaire "type" alphabetical, or numerical order, with proposed luminaire and accessories clearly indicated on each sheet.
- C. **Maintenance Data:** Submit maintenance data and parts list for each emergency lighting and accessory including "trouble-shooting" maintenance guide. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of the General Conditions of the Contract and other Division 26 sections.

**1.4 DELIVERY, STORAGE AND HANDLING:**

- A. Handle emergency lighting carefully to prevent damage, breaking, and scoring. Do not install damaged luminaires or components; replace with new.
- B. Store in clean, dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.

**PART 2 - PRODUCTS****2.1 ACCEPTABLE MANUFACTURERS:**

- A. **Manufacturers:** Subject to compliance with requirements, provide emergency lighting of one of the following (for each type of emergency luminaire), or match existing models:
  - 1. **Unitized Battery Powered Fixtures:**
    - a. Dual-Lite Inc.
    - b. Emergi-Lite Co.
  - 2. **Exit Signs:**
    - a. Acuity Lithonia.
  - 3. **Emergency Fluorescent Lamp Power Supplies:**
    - a. Dual-Lite Inc.
    - b. Lithonia Lighting Inc.

**2.2 EMERGENCY LIGHTING:**

- A. **General:** Provide lighting of sizes, types and ratings indicated; complete with but not necessarily limited to housings, energy efficient lamps, lamp holders, reflectors, energy-efficient ballasts, starters and wiring.
- B. **Wiring:** Provide wiring within fixtures for connection to branch circuit wiring as follows:
  - 1. NEC Type TFN for 120 & 277 volt, minimum No. 18 AWG.
- C. **Emergency Battery Powered Units:** Provide battery powered, self-contained units with solid-state, fully automatic charger, unit "Ready" light, transfer/brownout circuit and low-voltage battery disconnect.
  - 1. **Power Supplies:**
    - a. Provide unit with universal (multi-tap) transformer suitable for 120 or 277 VAC operation.



- b. Battery: Provide maintenance free lead-calcium battery for 12 VDC operation capable of supplying connected load for period of 1-1/2 hours to end voltage or 87-1/2 percent of nominal battery voltage.
2. Charger: Provide automatic battery charger with full recharging capability in 12 hours or less after full discharge.
3. Enclosure: Provide enclosure constructed in accordance with NEMA 1 standards. Provide low profile brushed aluminum canopy capable of being mounted on standard 3-1/2 inch or 4 inch octagonal, or 4 inch square wall box, or being fastened directly to wall.
4. Lamps: Provide two unit-mounted 12-volt, 7.2 watt sealed beam lamps.

OR

Provide two unit-mounted 12-volt, 18 watt sealed beam lamps.

5. Accessories: Provide the following accessories mounted on unit cabinet:
  - a. Unit test switch
  - b. Voltmeter
  - c. Ammeter
  - d. AC "ON" pilot light
  - e. High Charge Pilot Light
  - f. Battery life expectancy alarm
  - g. Wire guard (where indicated)
  - h. Heavy-duty wall mounting bracket

### 2.3 EMERGENCY FLUORESCENT LAMP POWER SUPPLY:

- A. General: Provide self-contained battery powered inverter unit for direct mounting in designated fluorescent or LED luminaires. Provide unit with fully automatic two rate charger, nickel-cadmium battery, AC "ON" pilot light, and test switch. Unit shall automatically transfer to battery supply on loss of normal AC power and shall operate one or two rapid start F32 fluorescent lamps with minimum output of 1350 lumens or LED lamps with equal lumens. Unit shall have minimum output of 3000 lumens for single high output lamp applications.

## PART 3 - EXECUTION

**3.1 INSPECTION:**

- A. Examine areas and conditions under which emergency lighting is to be installed, and substrate which will support lighting luminaires. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

**3.2 INSTALLATION OF EMERGENCY LIGHTING UNITS:**

- A. Install emergency lighting units at locations and heights as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC, NECA's "Standard of Installation", NEMA standards, and with recognized industry practices to ensure that lighting fulfills requirements.
- B. Coordinate with other electrical work as appropriate.
- C. Coordinate mounting of test switch indicator light and ballast prior to installation.

**3.3 ADJUSTING AND CLEANING:**

- A. Clean emergency lighting of dirt and debris upon completion of installation.
- B. Protect installed units from damage during remainder of construction period.

**3.4 GROUNDING:**

- A. Provide equipment grounding connections for emergency lighting as indicated. Tighten connections to comply with torque values specified in UL Std 486A to assure permanent and effective grounds.

**3.5 FIELD QUALITY CONTROL:**

- A. Upon completion of installation of emergency lighting and after building circuitry has been energized with normal power source, apply electrical energy to demonstrate capability and compliance with requirements. Test emergency lighting to demonstrate operation under emergency conditions. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.

**3.6 WARRANTY:**

- A. The Contractor shall guarantee all equipment including ballasts, lamps, luminaires, wiring, etc. free from inherent mechanical and electrical defects for five (5) years. Warranty period shall be from date of acceptance as set forth in the general conditions.

**END OF SECTION 26 52 00**

**SECTION 26 56 13 - POLES AND STANDARDS**

**PART 1 - GENERAL**

**1.1 DESCRIPTION OF WORK:**

- A. Extent of lighting poles and standards work is indicated by drawings and schedules.
  
- B. Applications of lighting poles and standards for this project include the following:
  - 1. Private roadways.
  - 2. Automobile parking lots.
  - 3. Vehicular storage areas.
  - 4. Promenades/plazas.
  - 5. Parks.
  - 6. Pedestrian walkways.
  - 7. Building entrances.

**1.2 QUALITY ASSURANCE:**

- A. **Manufacturers:** Firms regularly engaged in manufacture of electrical poles and standards of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
  
- B. **Installer's Qualifications:** Firm with at least 3 years of successful installation experience with projects utilizing electrical pole and standard work similar to that required for this project.

**1.3 DELIVERY, STORAGE AND HANDLING:**

- A. Store poles on decay-resistant treated skids at least one (1) foot above grade and vegetation. Support pole to prevent distortion and arrange to provide free air circulation.
  
- B. **Fiber Glass Poles:** Retain factory-applied pole wrappings until just before pole installation. Handle poles with web fabric straps.
  
- C. **Metal Poles:** Retain factory-applied pole wrappings until just before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

**1.4 SUBMITTALS:**

- A. **Product Data:** Submit manufacturer's data on electrical poles, standards and hardware; include certified dimension drawings for fabricated poles, standards and mast arms, if any.

**PART 2 - PRODUCTS****2.1 ACCEPTABLE MANUFACTURERS:**

- A. **Manufacturers:** Subject to compliance with requirements, provide products of one of the following (for each type of pole or standard).

- 1. **Wood Poles:**
  - a. Georgia-Pacific Corp.
- 2. **Standards:**
  - a. General Electric Co.
  - b. Appleton Electric Co.
  - c. Kirlin Company.
  - d. Lexington Standard Corp.
  - e. Lighting Div; Harvey Hubbell, Inc.
  - f. Spring City Electrical Mfg Co.
  - g. Union Metal Mfg Co.
- 3. **Metal Poles:**
  - a. Anchor Metals, Inc.
  - b. Marathon Steel Co.
  - c. Meyer Industries Div; ITT Corp.
  - d. Union Metal Mfg Co.
  - e. Valmont Industries, Inc.
- 4. **Reinforced Concrete Poles:**
  - a. Ameron Pole Products Co.

- b. Centrecon, Inc.
  - c. Dura-Stress Inc.
  - d. Raymond International Inc.
  - e. Union Metal Mfg Co.
  - f. Utility Vault Co.
5. Pole Hardware:
- a. A.B. Chance Co.
  - b. Dixie Electrical Mfg Co.
  - c. Stanley G. Flagg and Co., Inc.
  - d. Hercules, Inc.
  - e. Joslyn Mfg and Supply Co.
  - f. McGraw-Edison Co.
  - g. Preform Line Products Co.
  - h. Reliable Electric Co.
  - i. Utilities Service Co.

## 2.2 POLES AND STANDARDS:

- A. Laminated Wood Lighting Standards: Provide laminated wood, raceway-type, lighting standards, of types, sizes, materials and finishes indicated, pressure-treat with pentachlorophenol preservative; design to sustain wind velocities up to 100 mph; equip with hand access hole above and cable entrance hole below ground level, locate as indicated or, if not indicated, at manufacturer's standard locations to facilitate wiring, with matching plate to cover above-ground access hole. Provide standards with solid wood mast arms, where indicated.
- B. Utility-Type Wood Lighting Poles: Provide utility-type tapered solid wood lighting poles, with single crossarms, of sizes and type materials indicated; pressure-treat with creosote solution preservative.
  - 1. Wood Pole Accessories: Provide galvanized ferrous metal wood pole accessories including spool insulators, bolts, nuts, washers, crossarm gains, guy clamps and strain plates, insulator clevises, pole-top insulator pins, strand-eye anchor rods, lag screws, eye bolts, pole eye plates of sizes and types indicated

which comply with ANSI and NEMA standards, and meet erection and loading application requirements.

- C. **Prestressed Concrete Lighting Standards:** Provide prestressed concrete, raceway-type, lighting poles and standards, of sizes and types indicated, comprised of shafts and brackets; construct with the following construction features:
1. Configuration: Embedded type base and reinforcing sleeve with hand and cable entrance holes where indicated.
  2. Configuration: Anchor base type with hand hole and cover where indicated.
  3. Configuration: Transformer base type with access door and cover.
  4. **Prestressed Concrete Lighting Standard Accessories:** Provide accessories for prestressed concrete lighting standards, including anchor bolts, as recommended by lighting standard manufacturer, of sizes and materials needed to meet erection and loading application requirements.
- D. **Metal Lighting Standards:** Provide metal, raceway-type, lighting poles and standards, of sizes and types indicated, comprised of shaft and bracket; equip with grounding connection readily accessible from handhole or transformer base access door; and construct of the following materials and additional construction features:
1. Material: Stainless steel.
  2. Material: Galvanized steel.
  3. Material: Spun aluminum.
  4. Material: Extruded aluminum.
  5. Material: Bronze.
  6. Material: Cast iron.
  7. Configuration: Embedded type base and reinforcing sleeve with hand and cable entrance holes where indicated.
  8. Configuration: Anchor base type with hand hole and cover where indicated.
  9. Configuration: Transformer base type with access door and cover.
  10. **Metal Lighting Standard Accessories:** Provide accessories for metal lighting standards, including anchor bolts, as recommended by lighting standard manufacturer, of sizes and materials needed to meet erection and loading application requirements.

- E. **Metal Poles:** Provide galvanized steel, tapered tubular seamless shaft poles, of sizes and types indicated, with 1/4 inch bearing plates and ground sleeves for direct embedment. Provide removable step bolts 3/4 inch diameter and 6 inches long with threaded steel lugs welded to pole beginning 12 inches above finish grade. Space step bolts at 15 inches intervals on alternative sides of pole continuing to the top. Provide pole with adequately sized reinforced handhole complete with matching cover and located on climbing side of pole, 18 inches above grade level. Weld 1/2 inch grounding nut on shaft with accessibility from handhole. Design poles to withstand loads developed by 100 MPH wind pressure, as adjusted for height above ground level, structural shapes and cable/wire loading. Construct poles whose total length is over 40 feet in two sections for shipping purposes.
1. **Metal Pole Accessories:** Provide accessories for metal poles, including cross-arms, bolts, lifting eyes, and nuts as recommended by pole manufacturer, of sizes and materials needed to meet erection and loading application requirements.
- F. **Reinforced Concrete Poles:** Provide reinforced raceway-type concrete poles of sizes and types indicated. Design poles to withstand loads developed by 100 MPH wind pressure, as adjusted for height above ground level, structural shapes and cable/wire loading. Centrifugally spin concrete to attain a 28 day strength of 7000 psi. Fasten galvanized steel base plates to pole by using both the prestressing and reinforcing steel to transfer load on pole to anchor bolts. Embed base plate in concrete and cast as integral part of pole. Provide adequately sized cable entrance holes and handholes, where indicated, and with matching plate to cover above-ground access hole.
1. **Reinforced Concrete Pole Accessories:** Provide accessories for reinforced concrete poles, including anchor bolts and nuts, cross-arms, climbing rungs, and pole tops as recommended by pole manufacturer, of sizes and materials needed to meet erection and loading application requirements.
- G. **Lighting Brackets:** Provide corrosion-resistant, metal brackets, cantilevered without underbrace, of sizes and styles indicated; with straight tubular end section with external dimensions of 1-1/4 inch male NPS by 7-1/2 inch maximum length to accommodate slip-fitter luminaire attachments; with attaching hardware; constructed in compliance with NEMA Pub No. SH 5, and of the following construction:
1. **Material:** Wrought aluminum.
  2. **Material:** Cast aluminum.
  3. **Material:** Galvanized steel.



- H. Provide wood lighting brackets, of sizes, types, and styles indicated; capable of accommodating types of luminaires indicated (end-compatible with luminaire attachment); equip with attaching hardware; materials and finishes matched to laminated wood standards.

**PART 3 - EXECUTION****3.1 INSTALLATION OF LIGHTING POLES AND STANDARDS:**

- A. Install lighting poles and standards as indicated, in accordance with manufacturer's written instructions, in compliance with National Electrical Safety Code and NECA's "Standard of Installation" to ensure that poles and standards comply with requirements.
- B. To protect finishes, use belt slings or rope (not chain or cable) to raise and set finished poles and standards.
- C. Where poles/standards are indicated to be embedded in soil, set poles approximately 1/6 of pole length, but not less than 5 feet 6 inches depth below finish grade.
- D. Set poles and standards plumb. Support adequately during back-filling, or when anchoring to foundations.
- E. Provide sufficient space encompassing hand access and cable entrance holes for installation of cables from underground where indicated.

**3.2 GROUNDING:**

- A. Provide equipment bonding and grounding connections, sufficiently tight to assure permanent and effective grounds, where indicated, for installed poles and standards.
  - 1. Install 10-foot driven ground rod at each pole.
  - 2. Non-metallic Poles: Ground metallic components of lighting unit and foundations. Connect lighting to ground system with No. 6 AWG conductor.

**END OF SECTION 26 56 13**