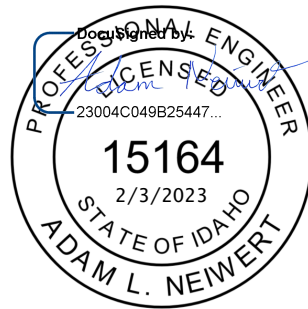




ELECTRICAL STANDARDS SPECIFICATIONS AND STANDARD DRAWINGS



FEBRUARY 2023

PROJECT NO. 221180-003

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PREFACE

These Electrical Standard Specifications and Drawings are intended to supplement the current edition of the Idaho Standards for Public Works Construction (ISPWC) and the City of Meridian Supplemental Specifications and Standard Drawings. In instances where the ISPWC does not clearly provide for additional requirement(s) of the City of Meridian, these specifications shall be used.

All construction within the City of Meridian, or within the jurisdiction of the City of Meridian, shall be completed in accordance with the ISPWC, the City of Meridian Supplemental Specifications and Standard Drawings, these specifications, the approved Construction Plans, all applicable State, Federal, County and local district regulations and Specifications; and in compliance with the electrical code, and City of Meridian Subdivision Ordinance. The more stringent of any of these standards shall be the controlling standards or specifications. The City of Meridian recognizes that the ISPWC and the City of Meridian Supplemental Specifications may not cover all situations that might be encountered; however, this does not release the Contractor from properly constructing the work.

Any supplemental specification that the City Engineer or a designated representative deems necessary for the proper construction of any work shall be prepared and issued to the Contractor prior to commencing construction.

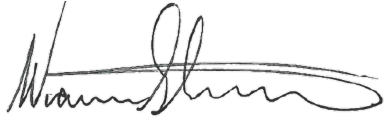
CITY ENGINEER'S LETTER

ELECTRICAL STANDARDS SPECIFICATIONS AND DRAWINGS CITY OF MERIDIAN, IDAHO

These Electrical Standard Specifications and Drawings were prepared for the City of Meridian. The need may arise to alter them to meet a specific design condition. If this occurs, all alterations, substitutions, or variances shall be approved in writing by the City Engineer or the designated representative.

In the event an error or omission is discovered in these Specifications and Drawings, whether through an oversight or a change in technology, the finder shall notify the City Engineer in writing so that the proper steps may be taken to make corrections.

It is further understood that the City of Meridian or its authorized agents are not responsible for errors or omissions.



Warren Stewart, P.E.
City Engineer

SECTION 26 05 00 – GENERAL REQUIREMENTS FOR ELECTRICAL WORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Specifications herein are City of Meridian Standards and are intended as a supplement to drawings, general provisions and Specification Sections created for each project.
- B. Division 26 contractor shall review all other division specifications and drawings for additional requirements.

1.2 REFERENCES

- A. Division 26 incorporates by reference the latest revisions of the following standards. They are part of Division 26 to the extent as specified and modified herein. In the event of conflict between the requirements of Division 26 and those of the listed documents, the requirements of Division 26 shall prevail.
- B. Unless otherwise specified, references to documents shall mean the documents in effect on the effective date of the Agreement. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.
- C. The following is a list of standards which may be referenced in this section:
 - 1. National Electrical Contractors Association (NECA): National Electrical Installation Standards.
 - 2. National Electrical Manufacturers Association (NEMA):
 - 3. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
 - 4. Z535.4, Product Safety Signs and Labels.
 - 5. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
 - 6. Underwriters Laboratories, Inc. (UL).

1.3 QUALITY ASSURANCE

- A. Comply with latest NEC, NFPA, UBC, UFC, UL and applicable Local and State Codes. Also comply with Utility Company regulations and industry standards and these Drawings.
- B. Work shall be done by only trained, licensed and experienced workmen familiar with the requirements.

- C. All microprocessor based equipment and software with equipment shall utilize 4 digits for the year part of all dates. A two digit date shall be an option for printing at Owner's preference.
- D. All equipment anchoring and mounting shall be in accordance with manufacturer's requirements for the seismic zone criteria.
- E. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories Inc. shall conform to those standards and shall have an applied UL listing mark or label.
- F. Provide materials and equipment acceptable to AHJ for Class, Division, and Group of hazardous area indicated.

1.4 EXTENT OF DRAWINGS / SPECIFICATION

- A. Drawings indicate intent and general layout of electrical systems for the Project. Drawings are partly diagrammatic and do not indicate all fittings and accessories which may be required. Provide such fittings and accessories as required to form a complete and operating system in general conformance with Specifications and Drawings.
- B. The basis of the mechanical and electrical design is the installation of equipment and motors as shown in the electrical one-line drawing(s) and load/panel schedules. In the event that different equipment motors are provided in order for the vendor's equipment to meet mechanical performance requirements, the contractor shall coordinate various suppliers, vendors, and subcontractors to change the required electrical conduit, circuits, breakers, motor control center sections, starters units and accessories, etc. as necessary to meet the vendor's equipment installation requirements of the National Electrical Code. The traits and characteristics of all provided materials, equipment, and devices shall meet the specifications. These changes to materials, equipment, and devices shall be at no cost to the Owner. Electrical submittal information shall be coordinated with the equipment and motors provided.

1.5 DISCREPANCIES

- A. Prior to submitting Bid, Contractor shall refer any apparent discrepancies or omissions to Engineer for clarification. The more stringent provisions shall take precedence where codes, Specifications and Drawings differ with one another. The Contractor shall Bid the more expensive requirement, unless discrepancy is addressed by Addendum prior to Bid.

1.6 TEMPORARY LIGHTING/POWER

- A. Provide temporary electrical power and lighting for all trades that require service during the course of this Project. Provide temporary service and distribution as required. Provide temporary power for all electrical equipment that will need to be installed due to the phased construction of this project. Comply with the NEC and OSHA requirements. Energy Costs by General Contractor.

1.7 SHIPMENT AND STORAGE

- A. Materials and equipment shall be stored in a manner to keep them dry and clean. Equipment and materials to be located indoors shall be stored indoors and sealed with plastic film wrap. Electrical and electronic equipment found stored or staged outdoors over night or in inclement weather shall be considered grounds for equipment rejection and shall be replaced at no cost to the Owner.

1.8 ELECTRIC SERVICE DIVISION OF RESPONSIBILITY

- A. Incoming underground electrical service facilities provided by Idaho Power Company as part of its normal obligation to customers is work provided outside this Contract. Under this Contract provide customer required service provisions and electrical work including, but not limited to, primary trench and backfill, primary duct system, transformer pad site preparation, transformer pad, and secondary facilities. Schedule and coordinate work of Idaho Power Company as required to provide electric service to the Work.
- B. Interior telecommunications central and station equipment (telephone instruments, telephone switches, data switches, and hubs, servers, software, etc. is work provided outside this Contract. Under this Contract provide raceways, fiber optic cable, outlet and junction boxes, cover plates, pull wires, as indicated.

1.9 SHOP DRAWING SUBMITTALS

- A. General: Follow the procedures specified in Project Specifications for Submittals. Submit for final and official approval through the General Contractor.
- B. Action Submittals:
 - 1. Manufacturers' data for the following:
 - 2. Electrical service components.
 - 3. Nameplates, signs, and labels.
 - 4. Circuit and raceway schedule

1.10 ENVIRONMENTAL CONDITIONS

- A. Unless otherwise specified, equipment and materials shall be sized and de-rated for the ambient conditions but not less than an ambient temperature of 40 degrees C at an elevation of 3000 feet without exceeding the manufacturer's stated tolerances.
- B. NEC area classifications per NFPA 820 and NFPA 497 are shown on the Drawings.
- C. All exterior areas not covered above or noted otherwise on the drawings, are classified wet and/or corrosive. Use materials and methods required for such areas.

1.11 CIRCUIT AND RACEWAY SCHEDULE

A. Contractor shall develop an approved circuit and raceway schedule. All circuits, raceways and cables shall be tagged at all terminations, switchgear, panels, MCCs, handholes, terminal junction boxes, and equipment in accordance with the approved numbers on the circuit/raceway schedule.

B. Circuit Schedule:

1. Schedule shall include assigned circuit designation, from (equipment or terminal junction box tag number), to (equipment or terminal junction box tag number), raceway designation of conduit containing the circuits, number/size/type of conductors, and applicable notes in a spreadsheet format.

C. Circuit Designation: Prefixes shall be followed by the end device equipment/instrument tag number per the following example:

Circuit number	=	P-SAER5MIX0006
P	=	Power wiring
-	=	Delimiter
SAER5MIX0006	=	Mixer 6, Aeration Basin 5

D. Raceway Schedule:

1. Schedule shall include assigned raceway designation, conduit size, circuit tag numbers in conduit, from (equipment, terminal junction box, or handhole tag number), to (equipment, terminal junction box, or handhole tag number), and applicable notes in a spreadsheet format.

2. Raceway Designation: Prefixes shall be followed by a facility code and sequential raceway number per the following example:

Raceway number	=	P-SAER5001
P	=	Raceway contains power wiring
-	=	Delimiter
SAER5	=	Facility code
001	=	Contractor assigned raceway number

1.12 EQUIPMENT COORDINATION

A. The Contractor is responsible to coordinate the equipment supplied from various manufacturers and vendors. This includes but is not limited to:

1. Obtaining specific information on equipment ratings and sizes and verifying the electrical components supplied meet, or match the requirements such as voltage, phase, frequency, starter types, etc.

2. Providing equipment that will fit within the space allocated and meet OSHA and N.E.C. clearances.

3. Coordination of the supplied equipment's electrical power and control requirements.
 4. Providing power and control equipment, wiring, and raceways to meet the requirements of the mechanical equipment supplied.
 5. Providing all necessary control wiring and components for any special requirements from an equipment manufacturer.
- B. The Contractor shall verify as a minimum:
1. Correct voltage, phase and frequency
 2. Size and space requirements
 3. Mounting requirements
 4. Correct motor starter type and NEMA size.
 5. Proper coordination with the controls and control system Integrator.
- C. Any discrepancies between the electrical equipment and other equipment shall be brought to the immediate attention of the Owner.
- D. The Contractor shall assure that no instrumentation or control interferences are created by the variable frequency drives (VFDs) or load wiring. The Contractor shall coordinate with the VFD manufacturer to provide necessary separation of conductors or shielding and/or filtering equipment as required by the VFD manufacturer. If interferences do occur, the Contractor shall be responsible to take corrective action at no additional cost to the Owner.

1.13 WIRING FOR VENDOR PACKAGES:

- A. Equipment specifications indicate when the Vendor is responsible for providing interconnection wiring between components of a Vendor package that are installed on separate skids or assemblies. In this circumstance, interconnection wiring between skids or assemblies in a Vendor package shall be by Vendor.
- B. Where equipment specifications do not specify Vendor furnished wiring between skids or assemblies in a Vendor package, the Contractor shall provide and install interconnection wiring between skids or assemblies per the Vendor's interconnection wiring requirements. Interconnection wiring between skids or assemblies in a Vendor package that is furnished and installed by the Contractor is not shown on the drawings.
- C. Determination of circuit requirements.
1. Coordinate cable/conductor requirements with the selected Vendors to determine the correct wiring required to interconnect the package system components/skids.
 2. Wiring between Vendor furnished components shipped on separate skids or assemblies shall conform to requirements specified in Project Specifications and City of Meridian Electrical Standards.

3. Wiring between the plant control system and Packages system components/skids are as shown on the drawings.
 4. Wiring between external power supplies and the packaged system components/skids are as shown on the drawings.
- D. Assign numbers and tagging for unscheduled circuit and raceway between Vendor furnished components on separate skids or assemblies. Coordinate this information in submittals, record drawings, and O&M manuals.
- E. Contract documents shall be updated in the record drawing set to include the work provided for wiring the vendor packages.

1.14 ARC FLASH MITIGATION METHODS

- A. The following mitigation method requirements shall apply to all power distribution and utilization equipment supplied for any products supplied on the project and applies to all equipment divisions in the Contract Documents. Refer to the NFPA-70 (NEC), and NFPA-70E (Electrical Safety in the Workplace) for equipment labeling requirements.
- B. Equipment Labels: Equipment labels shall be installed on the outside of the electrical equipment enclosure, cabinet, and panels to avoid opening the equipment to access the manufacture's data or the equipment ratings.
- C. Hinged Doors: Power distribution equipment shall have hinged rear doors where back access is shown.
- D. Insulated Power Bus and Insulated Cable Boots:
1. Provide insulated power bus in power distribution equipment where accessible to installers or maintenance workers.
 2. Provide cable boots for power conductor connections to insulate the exposed power conductor connections.
- E. Power and Control Equipment Separation:
1. Provide separation between power equipment within an enclosure, cabinet, or panel by the use of barriers, separate access doors, or by other means.
 2. Provide separation barriers between main breaker feeders coming into equipment and other termination points or bussing on the load side of the main breaker.
- F. Automatic Shutters: Provide automatic shutters, where possible, to close the access to the power bus when a power device is not engaged.
- G. Arc flash maintenance system for circuit breakers in other Division 26 specifications.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Where two or more units of the same class of material or equipment are required, provide products of a single manufacturer. Component parts of materials or equipment need not be products of the same manufacturer.
- B. Material and equipment installed in heated and ventilated areas shall be capable of continuous operation at their specified ratings within an ambient temperature range of 40 degrees F to 104 degrees F.
- C. Materials and equipment installed outdoors shall be capable of continuous operation at their specified rating within the ambient temperature range specified.



2.2 EQUIPMENT FINISH

- A. Manufacturer's standard finish color, except where specific color is indicated. If manufacturer has no standard color, finish equipment in accordance with light gray color finish as approved by Engineer.

2.3 NAMEPLATES

- A. Unless noted otherwise, nameplates shall be made of 1/16" thick machine engraved laminated phenolic having black letters (not less than 1/8" high for pushbuttons/selector switches, and 3/16" high for other electrical equipment) on white background or as shown on the drawings or other sections of the specifications.
- B. Nameplates shall be secured to equipment with stainless steel screws/fasteners.
- C. Nameplates shall be provided on all electrical devices, including but not limited to motor control equipment, MCC cubicles/cells/buckets, switchgear, panelboards, control stations, junction boxes, panels, harmonic filters, instruments, disconnect switches, indicating lights, meters, fire alarm panels/devices, and all electrical equipment enclosures.
- D. Equipment nameplates shall have both the equipment name and number.
- E. Nameplates for disconnect switches shall contain name and number, source tag number, as well as voltage and phases.
- F. Provide warning nameplates on all panels and equipment which contain multiple power sources. Lettering shall be white on red background.
- G. Nameplates on the interior of panels and fire alarm notification/detection devices shall be White Polyester with printed thermal transfer lettering and permanent pressure sensitive acrylic; TYTON 822 or equal. All nameplates shall include the equipment name and number (and function, if applicable).
- H. White Polyester Nameplates or equal shall also be provided on all interior equipment for manufactured electrical or control panels provided with wiring diagrams, including but not limited to relays, circuit breakers, power supplies, terminals, contactors, and other devices.

2.4 SIGNS AND LABELS

- A. Provide NFPA 820 ventilation system failure warning signs as shown on the drawings and in accordance with NEMA Z535.4.
- B. Provide warning sign and instructions to operator for gas detection alarm at both the detector and at a safe location prior to entering a potentially hazardous area. Sign to comply with NEMA Z535.4, ANSI Z535.2 and OSHA standards.
 - 1. “GAS DETECTION , WARNING, HARMFUL GAS IN AIR WHEN ACTIVE, EXIT BUILDING, VENTILATE”
 - 2. “GAS DETECTION , WARNING, HARMFUL GAS IN AIR WHEN ACTIVE, DO NOT ENTER, VENTILATE”

2.5 CONCRETE EQUIPMENT BASES

- A. Forms and Reinforcing Materials: As specified in Project Specifications.
- B. Concrete: 28-day compressive strength as specified in Project Specifications.
- C. RACEWAY AND CABLE LABELS
- D. Comply with ANSI A13.1, Table 3, for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
 - 1. Color: Black letters on white field.
 - 2. Legend: Indicates voltage, source, and location.
- E. Adhesive Labels: Preprinted, flexible, self-adhesive vinyl with legend overlaminated with a clear, weather- and chemical-resistant coating.
- F. Pretensioned, Wraparound Plastic Sleeves: Flexible, preprinted, color-coded, acrylic band sized to suit the diameter of the line it identifies and arranged to stay in place by pretensioned gripping action when placed in position.
- G. Colored Adhesive Tape: Self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.
- H. Underground-Line Warning Tape: Permanent, bright-colored, continuous-printed, vinyl tape.
 - 1. Not less than 6 inches wide by 4 mils thick.
 - 2. Compounded for permanent direct-burial service.
 - 3. Embedded continuous metallic strip or core.
 - 4. Printed legend indicating type of underground line.

- I. Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wraparound type with preprinted numbers and letters.

2.6 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.
 1. Minimum Width: 3/16-inch.
 2. Tensile Strength: 50 lb minimum.
 3. Temperature Range: Minus 40 to plus 185 deg F.
 4. Color: According to color-coding.
- B. Paint: Formulated for the type of surface and intended use.
 1. Primer for Galvanized Metal: Single-component acrylic vehicle formulated for galvanized surfaces.
 2. Primer for Concrete Masonry Units: Heavy-duty-resin block filler.
 3. Primer for Concrete: Clear, alkali-resistant, binder-type sealer.
 4. Enamel: Silicone-alkyd or alkyd urethane as recommended by primer manufacturer.

PART 3 - EXECUTION

3.1 GENERAL

- A. Electrical Drawings show general locations of equipment, devices, and raceway, unless specifically dimensioned. Contractor shall be responsible for actual location of equipment and devices and for proper routing and support of raceways, subject to approval of Engineer.
- B. Check approximate locations of light fixtures, switches, electrical outlets, equipment, and other electrical system components shown on Drawings for conflicts with openings, structural members, and components of other systems and equipment having fixed locations. In the event of conflicts, notify Engineer in writing.
- C. Install work in accordance with NECA Standard of Installation, unless otherwise specified.
- D. Keep openings in boxes and equipment closed during construction.
- E. Lay out work carefully in advance. Do not cut or notch any structural member or building surface without specific approval of Engineer. Carefully perform cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, paving, or other surfaces required for the installation, support, or anchorage of conduit, raceways, or other electrical materials and equipment. Following such work, restore surfaces to original condition.

- F. Unless otherwise detailed or dimensioned, electrical layout drawings are diagrammatic. The Contractor shall coordinate the field location of electrical material or equipment with the work of other disciplines and subcontractors. Minor changes in location of electrical material or equipment made prior to installation shall be made at no cost to the Owner.

3.2 EQUIPMENT INSTALLATION REQUIREMENTS

- A. Install components and equipment to provide the maximum possible headroom where mounting heights or other location criteria are not indicated.
- B. Install items level, plumb, and parallel and perpendicular to other building systems and components, except where otherwise indicated.
- C. Install equipment to facilitate service, maintenance, and repair or replacement of components. Connect for ease of disconnecting, with minimum interference with other installations.
- D. Give right of way to raceways and piping systems installed at a required slope.
- E. Equipment must be listed for the short circuit current available at each piece of equipment per NEC. Any equipment not meeting the AIC required rating shall be corrected or replaced to meet this requirement.

3.3 GENERAL INSTALLATION OF MATERIALS

- A. Install wires according to manufacturer's written instructions and NECA's "Standard of Installation."
- B. Conductor Splices: Keep to the minimum and comply with the following:
 - 1. Install splices and taps that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
 - 2. Use splice and tap connectors that are compatible with conductor material.
- C. Connect outlets and components to wiring systems and to ground as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque-tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening requirements specified in UL 486A.
- D. Install devices to securely and permanently fasten and support electrical components.
- E. Raceway Supports: Comply with NFPA 70 and the following requirements:
 - 1. Conform to manufacturer's recommendations for selecting and installing supports.
 - 2. Install individual and multiple raceway hangers and riser clamps to support raceways. Provide U bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.

3. Support parallel runs of horizontal raceways together on trapeze- or bracket-type hangers.
 4. Spare Capacity: Size supports for multiple conduits so capacity can be increased by a 25 percent minimum in the future.
 5. Support individual horizontal raceways with separate, malleable iron pipe hangers or clamps.
 6. Hanger Rods: 1/4-inch diameter or larger threaded steel, except as otherwise indicated.
 7. Spring Steel Fasteners: Specifically designed for supporting single conduits or tubing. May be used in lieu of malleable iron hangers for 1-1/2-inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings and for fastening raceways to channel and slotted angle supports in accordance with NEC.
 8. In vertical 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.
- F. Vertical Conductor Supports: Install simultaneously with conductors.
- G. Miscellaneous Supports: Install metal channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices except where components are mounted directly to structural features of adequate strength.
- H. Sleeves: Install for cable and raceway penetrations of concrete slabs and walls, except where core-drilled holes are used. Install for cable and raceway penetrations of masonry and fire-rated gypsum walls and of all other fire-rated floor and wall assemblies. Install sleeves during erection of concrete and masonry walls.
- I. Fastening: Unless otherwise indicated, securely fasten electrical items and their supporting hardware to the building structure. Perform fastening according to 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 by machine screws, welded threaded studs, or spring-tension clamps on steel.
 2. Threaded studs driven by a powder charge and provided with lock washers and nuts may be used instead of expansion bolts, machine screws, or wood screws.
 3. Welding to steel structure may be used only for threaded studs, not for conduits, pipe straps, or any other items.
 4. In partitions of light steel construction use sheet-metal screws.
 5. Drill holes in concrete beams so holes more than 1-1/2 inches deep do not cut main reinforcing bars.

6. Drill holes in concrete so holes more than 3/4-inch deep do not cut main reinforcing bars.
 7. Fill and seal holes drilled in concrete and not used.
 8. Select fasteners so the load applied to any fastener does not exceed 25 percent of the proof-test load.
- J. Install concrete pads and bases where indicated.
- K. Install utility-metering equipment according to utility company's written requirements. Provide grounding and empty conduits as required by company.

3.4 ANCHORING AND MOUNTING

- A. Equipment anchoring and mounting shall be in accordance with manufacturer's requirements for seismic zone criteria given in Project Specifications.

3.5 COMBINING CIRCUITS INTO COMMON RACEWAY

- A. Drawings show each homerun circuit to be provided. Do not combine power or control circuits into common raceways without authorization of Engineer.
- B. Homerun circuits shown on Drawings indicate functional wiring requirements for power and control circuits. Circuits may be combined into common raceways in accordance with the following requirements:
1. Analog control circuits from devices in same general area to same destination.
 - a. No power or AC discrete control circuits shall be combined in same conduit with analog circuits.
 - b. No Class 2 or Class 3 circuits including, but not limited to, HVAC control circuits, fire alarm circuits, paging system circuits shall be combined with power or Class 1 circuits.
 - c. Analog circuits shall be continuous from source to destination. Do not add TJB, splice, or combine into a multi-pair cable without authorization of Engineer.
 - d. Raceways: Do not exceed 40 percent fill.
 - e. Changes shall be documented on record drawings.
 2. Discrete control circuits from devices in the same general area to the same destination.
 - a. No power or analog control circuits shall be combined in same conduit with discrete circuits.

- b. No Class 2 or Class 3 circuits including, but not limited to, HVAC control circuits, fire alarm circuits, and paging system circuits shall be combined with power or Class 1 circuits.
 - c. Raceways: Do not exceed 40 percent fill.
 - d. Changes shall be documented on record drawings.
3. Power circuits from loads in same general area to same source location (such as: panelboard, switchboard, low voltage motor control center).
- a. Lighting Circuits: Combine no more than three circuits to a single raceway. Contractor shall be responsible for increasing conduit and conductor size if derating is required by NEC.
 - b. Receptacle Circuits, 120-Volt Only: Combine no more than three circuits to a single raceway. Provide a separate neutral conductor for each circuit. Contractor shall be responsible for increasing conduit and conductor size if derating is required by NEC.
 - c. All Other Power Circuits: Do not combine power circuits without authorization of Engineer.

3.6 NAMEPLATES, SIGNS, AND LABELS

A. Arc Flash Protection Warning Signs:

- 1. Field mark switchboards, motor control centers, and panelboards to warn qualified persons of potential arc-flash hazards. Locate marking so to be clearly visible to persons before working on energized equipment.
- 2. Use arc flash hazard boundary, energy level, PPE level and description, shock hazard, bolted fault current, and equipment name from Engineer as basis for warning signs.
- 3. Engineer to provide arc flash warning signs. Contractor shall coordinate with Engineer.

B. Equipment Nameplates:

- 1. Provide a nameplate to label electrical equipment including switchgear, switchboards, motor control centers, panelboards, motor starters, transformers, terminal junction boxes, disconnect switches, switches and control stations.
- 2. Switchgear, motor control center, transformer, and terminal junction box nameplates shall include equipment designation.
- 3. Disconnect switch, starter, and control station nameplates shall include name and number of equipment powered or controlled by that device.

4. Switchboard and panelboard nameplates shall include equipment designation, service voltage, and phases.
- C. Procedural Signs:
1. Provide signs as shown on Drawings at each NFPA 820 ventilation dual light signaling system.
- D. Equipment Labels:
1. Equipment labels shall be installed on the outside of the electrical equipment enclosure, cabinet, and panels to avoid opening the equipment to access the manufacture's data or the equipment ratings.

3.7 LABEL INSTALLATION

- A. Identification Materials and Devices: Install at locations for most convenient viewing without interference with operation and maintenance of equipment.
- B. Lettering, Colors, and Graphics: Coordinate names, abbreviations, colors, and other designations with corresponding designations in the Contract Documents or with those required by codes and standards. Use consistent designations throughout Project.
- C. Sequence of Work: If identification is applied to surfaces that require finish, install identification after completing finish work.
- D. Self-Adhesive Identification Products: Clean surfaces before applying.
- E. Install painted identification according to manufacturer's written instructions and as follows:
1. Clean surfaces of dust, loose material, and oily films before painting.
 2. Prime surfaces using type of primer specified for surface.
 3. Apply one intermediate and one finish coat of enamel.
- F. Color Identification of Junction boxes: Identify with spray paint. Apply colors as follows:
1. Fire Alarm: Red
- G. Caution Labels for Indoor Boxes and Enclosures for Power and Lighting: Install pressure-sensitive, self-adhesive labels identifying system voltage with black letters on orange background. Install on exterior of door or cover.
- H. Circuit Identification Labels on all devices, boxes, pull boxes, conduits, etc.: Provide printed labels, identifying circuit and source origin (panel and circuit number). Install labels externally.
1. Exposed Boxes: Label indicating panel and circuit designation.

2. Concealed Boxes: Permanent black marker indicating panel and circuit designation.
- I. Paths of Underground Electrical Lines: During trench backfilling, for exterior underground power, control, signal, and communication lines, install continuous underground plastic line marker located directly above line at 6 to 8 inches below finished grade. Where width of multiple lines installed in a common trench or concrete envelope does not exceed 16 inches overall, use a single line marker. Install line marker for underground wiring, both direct-buried cables and cables in raceway.
- J. Color-Coding of Secondary Phase Conductors: Use the following colors for service, feeder, and branch-circuit phase conductors:
 1. 208/120-V Conductors:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 - d. Neutral: White.
 - e. Ground: Green.
 2. 480/277-V Conductors:
 - a. Phase A: Brown.
 - b. Phase B: Orange
 - c. Phase C: Yellow.
 - d. Neutral: Gray.
 - e. Ground: Green.
 3. Factory apply color the entire length of conductors, except the following field-applied, color-coding methods may be used instead of factory-coded wire for sizes larger than No. 6AWG:
 - a. Colored, pressure-sensitive plastic tape in half-lapped turns for a distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Use 1 inch wide tape in colors specified. Adjust tape bands to avoid obscuring cable identification markings.
- K. Power-Circuit Identification: Phenolic tags or aluminum, wraparound marker bands for cables, feeders, and power circuits in vaults, pull and junction boxes, manholes, and switchboard rooms.
 1. Legend: 1/4-inch steel letter and number stamping or embossing with legend corresponding to indicated circuit designations.
 2. Tag Fasteners: Nylon cable ties.

3. Band Fasteners: Integral ears.
- L. Apply identification to all conductors, conduits, and cables as follows:
1. Conductors to Be Extended in the Future: Indicate source and circuit numbers.
 2. Power or Lighting Circuits: Identify each conductor with source, voltage, circuit number, and phase. Use color-coding to identify circuits' voltage and phase.
 3. Control and Communication Circuits: Identify each conductor by its system and circuit designation. Use a consistent system of tags, color-coding, or cable marking tape.
 4. All conduits to be identified with location of origin inside of panelboard, MCC's, Terminal junction boxes, PLC and similar enclosures.
 5. Any and all future conduit stubs to be labeled with source of origin.
- M. Apply warning, caution, and instruction signs as follows:
1. Warnings, Cautions, and Instructions: Install to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.
 2. Emergency Operation: Install engraved laminated signs with white legend on red background with minimum 3/8-inch high lettering for emergency instructions on power transfer, load shedding, and other emergency operations.
- N. Equipment Identification Labels: Engraved plastic laminate. Install on each unit of equipment, including central or master unit of each system. This includes power, lighting, communication, signal, and alarm systems, unless units are specified with their own self-explanatory identification. Unless otherwise indicated, provide a single line of text with 1/2-inch high lettering on 1-1/2 inch high label; where two lines of text are required, use labels 2 inches high. Use white lettering on black field. Apply labels for each unit of the following categories of equipment using mechanical fasteners:
1. Panelboards, electrical cabinets, and enclosures.
 2. Access doors and panels for concealed electrical items.
 3. Electrical switchgear and switchboards.
 4. Emergency system boxes and enclosures.
 5. Disconnect switches.
 6. Enclosed circuit breakers.
 7. Motor starters.

8. Push-button stations.
 9. Power transfer equipment.
 10. Contactors.
 11. Remote-controlled switches.
 12. Control devices.
 13. Transformers.
 14. Battery racks.
 15. Power-generating units.
- O. Arc Flash & Shock Hazard labels: Equipment shall be legibly marked in the field with the maximum available fault current based upon the arc flash protection study. The label shall include the date the fault current calculation was performed. The label shall be of type durable enough to withstand the environment for which it is installed.
- P. For panelboards, provide circuit schedules with identification of items controlled by each breaker. Indicate items controlled and room name where appropriate for Owners convenience. Final schedules shall be typed or printed for clarity. Hand written schedules are not acceptable. Schedules shall be posted inside each panel door mounted in transparent card holder upon project completion.

3.8 SEQUENCING AND SCHEDULING

- A. Coordinate electrical equipment installation with other building components.
- B. Arrange for chases, slots, and openings in building structure during progress of construction to allow for electrical installations.
- C. Coordinate installing required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- D. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work. Coordinate installing large equipment requiring positioning prior to closing in the building.
- E. Coordinate connecting electrical service to components furnished under other Sections.
- F. Coordinate connecting electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Coordinate requirements for access panels and doors where electrical items requiring access are concealed by finished surfaces.

3.9 MOTOR CONNECTIONS

- A. Verify that the motors are purchased with the correct size motor termination boxes for the circuit content specified in the conduit and cable schedules or submit custom fabrication drawing indicating proposed motor termination box material, size, gasket, termination kit, grounding terminal, boot type insulated motor lead connection (T&B type MSC, or equal), and motor terminal box connection/support system. Verify the motor termination box location prior to raceway rough-in.

3.10 CONDUCTOR INSTALLATION

- A. An enclosure containing disconnecting means, overcurrent devices, or electrical equipment shall not be used as a wireway or raceway for conductors not terminating within the enclosure. Provide wireways, raceways, termination boxes, or junction boxes external to the enclosure for the other conductors.

3.11 LOAD BALANCE

- A. Drawings and Specifications indicate circuiting to electrical loads and distribution equipment.
- B. Balance electrical load between phases as nearly as possible on switchboards, panelboards, motor control centers, and other equipment where balancing is required.
- C. When loads must be reconnected to different circuits to balance phase loads, maintain accurate record of changes made, and provide circuit directory that lists final circuit arrangement.

3.12 SUBSTANTIAL COMPLETION

- A. At Substantial Completion of Project, be ready to demonstrate the following list of items below. If this is not possible, inform the General Contractor and Engineer no less than 1 week prior to Engineer's visitation of the site for Substantial Completion.
- B. Demonstrate the operation and test of the emergency lighting system.
- C. Demonstrate the main service ground, bonding to neutral and resistance readings obtained at time of installation. This will involve having some covers removed from the main panels at the time of the Engineer's visitation.
- D. All electrical systems and items specified shall be installed and operational.
- E. Demonstrate exterior lighting controls.
- F. Demonstrate the operation of all emergency power systems including generators, automatic transfer switch, uninterruptible power supplies and inverter systems.
- G. Contractor to coordinate installation of Arc Flash Labels in accordance with the City of Meridian Standards.

- H. Demonstrate compliance with IEEE 519 for harmonic distortion within “Idaho Power Company’s” distortion limit requirement for each project as coordinated with Idaho Power and IEEE. Distortion limits apply to the entire plant load measured at the primary meter. This point in the system shall be defined as the point of common coupling (PCC). Meeting these requirements is a condition of service and a requirement of this project. Refer to Section 26 29 23 – Low Voltage Adjustable Frequency Drives.

3.13 CLEANING AND TOUCHUP PAINTING

- A. Cleaning: Throughout the Work, clean interior and exterior of devices and equipment by removing debris and vacuuming.
- B. Touchup Paint:
 - 1. Touchup scratches, scrapes and chips on exterior and interior surfaces of devices and equipment with finish matching type, color, and consistency and type of surface of original finish.
- C. If extensive damage is done to equipment paint surfaces, refinish entire equipment in a manner that provides a finish equal to or better than factory finish, that meets requirements of Specification, and is acceptable to Engineer.

3.14 PROTECTION FOLLOWING INSTALLATION

- A. Protect materials and equipment from corrosion, physical damage, and effects of moisture on insulation and contact surfaces.
- B. When equipment intended for indoor installation is installed at Contractor’s convenience in areas where subject to dampness, moisture, dirt or other adverse atmosphere until completion of construction, ensure adequate protection from these atmospheres is provided and acceptable to Engineer.

3.15 RECORD DOCUMENTS

- A. Prepare Record Documents in accordance with the requirements in Project Specifications. In addition to the requirements specified in the Project Specifications, indicate the following installed conditions:
- B. Actual location of all electrical service gear/feeders, panel/motor/special equipment feeders, all major underground or under slab conduits, all conduit stubs for future use, any change in branch circuitry from Drawings, key junction boxes and pull boxes not indicated on Drawings, any control locations or indicator lights not shown on Drawings.
- C. Addendum items, Change Order items and all changes made to Drawings from Bidding phase through to Project completion.
- D. Actual equipment and materials installed. Where manufacturer and catalog number are indicated on Drawings, generally or in fixture or equipment schedules, change to reflect actual products installed.

- E. Change service panel and branch panel breaker locations and schedules to reflect actual installed conditions.
- F. Maximum available fault current at each electrical panel is required to be calculated and reflected on the one line diagram. AIC ratings shall be reflected on panel schedules. Panels and equipment must be braced to withstand available fault current per NEC.
- G. Comply with Section 26 05 73 – Electrical Systems Analysis and provide a copy of the arc flash protection study to the City of Meridian that includes all applicable data collected and SKM file for records.

3.16 MAINTENANCE MANUALS

- A. Compile Operating and Maintenance Manuals for the electrical systems and equipment. The manuals shall be provided to the Engineer for approval complete and at one time, prior to requesting final payment. Partial or separate data will be returned for completion.
- B. Manuals shall be assembled in three-ring binders. Binders shall be 3 inch thick or less and have slip sleeve jacket on binder side and front. More than one binder shall be used for each set of data if required to prevent overfilling of one binder. All information shall be arranged in Sections and each Section shall have a blank buff colored, heavy paper divider with a protruding tab clearly labeled. Sections shall be arranged in the same order that the equipment is listed in the Specification and each Specification Section shall have a separate tab. Shop Drawings which are larger than 8-1/2-inch by 11 inch shall be individually folded so they are 8-1/2-inch by 11 inch or less and inserted behind the appropriate tab.
- C. Tabs shall be labeled and arranged as follows:
 - 1. Index: Furnish under the first tab an index of Sections listing name of Section and Specification numbers.
 - 2. Equipment Manufacturers: Furnish under the second tab a complete typed list of equipment suppliers and manufacturers' representative including type of equipment, name, address, and phone number. The company listed here should be the one which could furnish replacement parts and offer technical information about the equipment.
 - 3. Product Literature: Each tab, starting with the third shall contain the name of a Specification Section. Behind each tab shall be the previously submitted and approved Shop Drawing, factory published operation and maintenance instructions and parts lists. Also include description of function, normal operating characteristics and limitations, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions. Servicing instructions and lubrication charts and schedules.

- D. Upon completion and approval of the booklets, one copy shall be given to the Engineer, and two (1-papper copy and 1- electronic copy) to the Owner. Using the booklet, the Electrical Contractor shall explain in detail and instruct the Owner's operating personnel in the correct operation and maintenance of the equipment.

END OF SECTION 26 05 00

SECTION 26 05 04 - BASIC ELECTRICAL MATERIALS AND METHODS

PART 1—GENERAL

1.1 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. ASTM International (ASTM):
 - a. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
 - b. A1011/A1011M, Standard Specification for Steel, Sheet, and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low Alloy and High-Strength Low Alloy Formability.
 - c. E814, Method of Fire Tests of Through-Penetration Fire Stops.
 2. Canadian Standards Association (CSA).
 3. Institute of Electrical and Electronics Engineers, Inc. (IEEE): 18, Standard for Shunt Power Capacitors.
 4. International Society of Automation (ISA): RP12.06.01, Wiring Practices for Hazardous (Classified) Locations Instrumentation—Part 1: Intrinsic Safety.
 5. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
 - b. AB 1, Molded Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures.
 - c. C12.1 Code for Electricity Metering
 - d. C12.6 Phase-Shifting Devices Used in Metering, Marking and Arrangement of, Terminals for
 - e. CP 1, Shunt Capacitors.
 - f. ICS 2, Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 Volts.
 - g. ICS 5, Industrial Control and Systems: Control Circuit and Pilot Devices.
 - h. KS 1, Enclosed and Miscellaneous Distribution Switches (600 Volts Maximum).
 6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).

7. Underwriters Laboratories Inc. (UL):
 - a. 98, Standard for Enclosed and Dead-Front Switches.
 - b. 248, Standard for Low Voltage Fuses.
 - c. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
 - d. 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
 - e. 508, Standard for Industrial Control Equipment.
 - f. 810, Standard for Capacitors.
 - g. 943, Standard for Ground-Fault Circuit-Interruptioners.
 - h. 1059, Standard for Terminal Blocks.
 - i. 1479, Fire Tests of Through-Penetration Fire Stops.

1.2 SUBMITTALS

A. Action Submittals:

1. Provide manufacturers' data for the following:
 - a. Control devices.
 - b. Control relays.
 - c. Circuit breakers.
 - d. Fused switches.
 - e. Nonfused switches.
 - f. Timers.
 - g. Fuses.
 - h. Terminal blocks.
 - i. Magnetic control relays.
 - j. Time delay relays.
 - k. Magnetic contactors.
 - l. Support and framing channel.

- m. Firestopping.
- n. Padmount terminating equipment
- o. Enclosures: Include enclosure data for products having enclosures.

1.3 EXTRA MATERIALS

- A. Furnish, tag, and box for shipment and storage the following spare parts and special tools:
 - 1. Fuses, 0 to 600 Volts: Six of each type and each current rating installed.

PART 2 - PRODUCTS

2.1 MOLDED CASE CIRCUIT BREAKER THERMAL MAGNETIC, LOW VOLTAGE

- A. General:
 - 1. Type: Molded case.
 - 2. Trip Ratings: 15-800 amps.
 - 3. Voltage Ratings: 120, 240, 277, 480, and 600V ac.
 - 4. Suitable for mounting and operating in any position.
 - 5. NEMA AB 1 and UL 489.
- B. Operating Mechanism:
 - 1. Overcenter, trip-free, toggle type handle.
 - 2. Quick-make, quick-break action.
 - 3. Locking provisions for padlocking breaker in open position.
 - 4. ON/OFF and TRIPPED indicating positions of operating handle.
 - 5. Operating handle to assume a center position when tripped.
- C. Trip Mechanism:
 - 1. Individual permanent thermal and magnetic trip elements in each pole.
 - 2. Variable magnetic trip elements with a single continuous adjustment 3X to 10X for frames greater than 100 amps.
 - 3. Two and three pole, common trip.
 - 4. Automatically opens all poles when overcurrent occurs on one pole.

5. Test button on cover.
 6. Calibrated for 40 degrees C ambient, unless shown otherwise.
 7. Do not provide single-pole circuit breakers with handle ties where multi-pole circuit breakers are shown.
- D. Short Circuit Interrupting Ratings:
1. Equal to, or greater than, available fault current or interrupting rating shown.
- E. Ground Fault Circuit Interrupter (GFCI): Where indicated, equip breaker as specified above with ground fault sensor and rated to trip on 5-mA ground fault within 0.025 second (UL 943, Class A sensitivity, for protection of personnel).
1. Ground fault sensor shall be rated same as circuit breaker.
 2. Push-to-test button.
- F. Equipment Ground Fault Interrupter (EGFI): Where indicated, equip breaker specified above with ground fault sensor and rated to trip on 30-mA ground fault (UL-listed for equipment ground fault protection).
- G. Magnetic Only Type Breakers: Where shown; instantaneous trip adjustment which simultaneously sets magnetic trip level of each individual pole continuously through a 3X to 10X trip range.
- H. Accessories: Shunt trip, auxiliary switches, handle lock ON devices, mechanical interlocks, key interlocks, unit mounting bases, double lugs as shown or otherwise required. Shunt trip operators shall be continuous duty rated or have coil-clearing contacts.
- I. Connections:
1. Supply (line side) at either end.
 2. Mechanical wire lugs, except crimp compression lugs where shown.
 3. Lugs removable/replaceable for breaker frames greater than 100 amperes.
 4. Suitable for 75 degrees C rated conductors without derating breaker or conductor ampacity.
- J. Enclosures for Independent Mounting:
1. See Article Enclosures.
 2. Service Entrance Use: Breakers in required enclosure and required accessories shall be UL 489 listed.
 3. Interlock: Enclosure and switch shall interlock to prevent opening cover with switch in the ON position. Provide bypass feature for use by qualified personnel.

2.2 FUSED SWITCH, INDIVIDUAL, LOW VOLTAGE

- A. UL 98 listed for use and location of installation.
- B. NEMA KS 1.
- C. Short Circuit Rating: 200,000 amps RMS symmetrical with Class R, Class J, or Class L fuses installed.
- D. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.
- E. Connections:
 - 1. Mechanical lugs, except crimp compression lugs where shown.
 - 2. Lugs removable/replaceable.
 - 3. Suitable for 75 degrees C rated conductors at NEC 75 degrees C ampacity.
- F. Fuse Provisions:
 - 1. 30-amp to 600-amp rated shall incorporate rejection feature to reject all fuses except Class R.
 - 2. 601-amp rated and greater shall accept Class L fuses, unless otherwise shown.
- G. Enclosures: See Article Enclosures.
- H. Interlock: Enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.
- I. Auxiliary Contact:
 - 1. As required to disconnect adjustable frequency drive control power or other auxiliary controls and disconnecting means, as directed by the drawings.
 - 2. Operation: Make before power contacts make and break before power contacts break.
 - 3. Contact Rating: 7,200VA make, 720VA break, at 600V, NEMA ICS 5 Designation A600.
- J.

2.3 NONFUSED SWITCH, INDIVIDUAL, LOW VOLTAGE

- A. NEMA KS 1.
- B. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.

- C. Lugs: Suitable for use with 75 degrees C wire at NEC 75 degrees C ampacity.
- D. Auxiliary Contact:
 - 1. As required to disconnect adjustable frequency drive control power or other auxiliary controls and disconnecting means, as directed by the drawings.
 - 2. Operation: Make before power contacts make and break before power contacts break.
 - 3. Contact Rating: 7,200VA make, 720VA break, at 600V, NEMA ICS 5 Designation A600.
- E. Enclosures: See Article Enclosures.
- A. Interlock: Enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.

2.4 FUSE, 250-VOLT AND 600-VOLT

- A. Power Distribution, General:
 - 1. Current-limiting, with 200,000 ampere rms interrupting rating.
 - 2. Provide to fit mountings specified with switches.
 - 3. UL 248.
- B. Power Distribution, Ampere Ratings 1 Amp to 600 Amps:
 - 1. Class: RK-1.
 - 2. Type: Dual element, with time delay.
 - 3. Manufacturers and Products:
 - a. Bussmann; Types LPS-RK (600 volts) and LPN-RK (250 volts).
 - b. Littelfuse; Types LLS-RK (600 volts) and LLN-RK (250 volts).
- C. Power Distribution, Ampere Ratings 601 Amps to 6,000 Amps:
 - 1. Class: L.
 - 2. Double O-rings and silver links.
 - 3. Manufacturers and Products:
 - a. Bussmann; Type KRP-C.
 - b. Littelfuse, Inc.; Type KLPC.

- D. Cable Limiters:
 - 1. 600V or less; crimp to copper cable, bolt to bus or terminal pad.
 - 2. Manufacturer and Product: Bussmann; K Series.
- E. Ferrule:
 - 1. 600V or less, rated for applied voltage, small dimension.
 - 2. Ampere Ratings: 1/10 amp to 30 amps.
 - 3. Dual-element time-delay, time-delay, or nontime-delay as required.
 - 4. Provide with blocks or holders as indicated and suitable for location and use.
 - 5. Manufacturers:
 - a. Bussmann.
 - b. Littlefuse, Inc.

2.5 CONTROL DEVICES

- A. General Requirement: Control devices mounted to an enclosure door or box are required to have finger safe terminals or be provided with finger safe guards on terminals to prevent accidental contact to live terminals where voltage may be present.
- B. HOA Padlocking Cover: Provide padlocking cover on all HOA switches. Cover shall be clear plastic. AB 800T or approved equal.
- C. Potentiometer Units: Provide ohm value for the application. Provide with back plate marked with 0-100% in 10% increments.
 - 1. Legend Plat Label: SPEED
- D. Contact Rating: 7,200VA make, 720VA break, at 600V, NEMA ICS 5 Designation A600. Provide bifurcated contacts for 24Vdc switching.
- E. Selector Switch Operating Lever: Standard.
- F. Emergency stop/close buttons shall be 2-position, push-pull/twist release type with red jumbo mushroom head.
- G. Indicating Light: press-to-test LED, full voltage.
- H. Pushbutton Color:
 - 1. ON or START: Black.
 - 2. OFF or STOP: Red.

- I. Pushbutton and selector switch lockable in OFF position where indicated.
- J. Legend Plate:
 - 1. Material: Aluminum.
 - 2. Engraving: Enamel filled in high contrasting color.
 - 3. Text Arrangement: 11-character/spaces on one line, 14-character/spaces on each of two lines, as required, indicating specific function.
 - 4. Letter Height: 7/64-inch.
- K. Manufacturers and Products:
 - 1. Allen Bradley 800H or 800T, or equivalent.

2.6 INDICATING LAMP COLORS

- A. All indicating lamps shall have an integrated lamp-test function or a common lamp test switch for all lamps on a single line-up of equipment.
- B. Unless otherwise specified, indicating lights shall be equipped with colored lenses in accordance with the following schedule:

Color	Function	Example
Green	Run, open valve	Equipment operating, motor running
Red	Stopped, Closed valve	Alarm, end of cycle, motor stopped
White or clear	Normal condition, Ready	Control power on, status OK
Amber (yellow)	Abnormal condition	Failure of equipment or status abnormal, fault condition

2.7 TERMINAL BLOCK, 600 VOLTS

- A. UL 486E and UL 1059.
- B. Size components to allow insertion of necessary wire sizes.
- C. Capable of termination of control circuits entering or leaving equipment, panels, or boxes.
- D. Screw clamp compression, dead front barrier type, with current bar providing direct contact with wire between compression screw and yoke.
- E. Yoke, current bar, and clamping screw of high strength and high conductivity metal.
- F. Yoke shall guide all strands of wire into terminal.
- G. Current bar shall ensure vibration-proof connection.

- H. Terminals:
 - 1. Capable of wire connections without special preparation other than stripping.
 - 2. Capable of jumper installation with no loss of terminal or rail space.
 - 3. Individual, rail mounted.
- I. Marking system, allowing use of preprinted or field-marked tags.
- J. Manufacturers:
 - 1. Weidmuller, Inc.
 - 2. Ideal.
 - 3. Electrovert USA Corp.

2.8 MAGNETIC CONTROL RELAY

- A. Industrial control with field convertible contacts rated 10 amps continuous, 7,200VA make, 720VA break.
- B. NEMA ICS 2, Designation: A600 (600 volts).
- C. Time Delay Relay Attachment:
 - 1. Pneumatic type, timer adjustable from 0.2 second to 60 seconds (minimum).
 - 2. Field convertible from ON delay to OFF delay and vice versa.
- D. Latching Attachment: Mechanical latch, having unlatching coil and coil clearing contacts.
- E. Manufacturers and Products:
 - 1. Eaton/Cutler-Hammer; Type M-600.
 - 2. General Electric Co.; Type CR120B.

2.9 TIME DELAY RELAY

- A. Industrial relay with contacts rated 5 amps continuous, 3,600VA make, 360VA break.
- B. NEMA ICS 2 Designation: B150 (150 volts).
- C. Solid-state electronic, field convertible ON/OFF delay.
- D. One normally open and one normally closed contact (minimum).
- E. Repeat accuracy plus or minus 2 percent.
- F. Timer adjustment from 1 second to 60 seconds, unless otherwise indicated on Drawings.

G. Manufacturers and Products:

1. Square D Co.; Type F.
2. Eaton/Cutler-Hammer.
3. General Electric Co.

2.10 SUPPORT AND FRAMING CHANNELS

A. Carbon Steel Framing Channel:

1. Material: Rolled, mild strip steel, 12-gauge minimum, ASTM A1011/A1011M, Grade 33.
2. Finish: Hot-dip galvanized after fabrication.

B. Paint Coated Framing Channel: Carbon steel framing channel with electro-deposited rust inhibiting acrylic or epoxy paint.

C. PVC Coated Framing Channel: Carbon steel framing channel with 40-mil polyvinyl chloride coating.

D. Stainless Steel Framing Channel: Rolled, ASTM A167, Type 316 stainless steel, 12-gauge minimum.

E. Manufacturers:

1. B-Line Systems, Inc.
2. Unistrut Corp.
3. Aickinstrut.

2.11 FIRESTOPS

A. General:

1. Provide UL 1479 classified hourly fire-rating equal to, or greater than, the assembly penetrated.
2. Prevent the passage of cold smoke, toxic fumes, and water before and after exposure to flame.
3. Sealants and accessories shall have fire-resistance ratings as established by testing identical assemblies in accordance with ASTM E814, by Underwriters Laboratories Inc., or other testing and inspection agency acceptable to authorities having jurisdiction.

B. Firestop System:

1. Formulated for use in through-penetration firestopping around cables, conduit, pipes, and duct penetrations through fire-rated walls and floors.
2. Fill, Void, or Cavity Material: 3M Brand Fire Barrier Caulk CP25, Putty 303, Wrap/Strip FS195, Composite Sheet CS195 and Penetration Sealing Systems 7902 and 7904 Series.
3. Two-Part, Foamed-In-Place, Silicone Sealant: Dow Corning Corp. Fire Stop Foam, General Electric Co. Pensil 851.

2.12 ENCLOSURES

- A. Finish: Sheet metal structural and enclosure parts shall be completely painted using an electrodeposition process so interior and exterior surfaces as well as bolted structural joints have a complete finish coat on and between them.
- B. Color: Manufacturer’s standard color (gray) baked-on enamel, unless otherwise shown.
- C. Barriers: Provide metal barriers within enclosures to separate wiring of different systems and voltage.
- D. Enclosure Selections: Except as shown otherwise, provide electrical enclosures according to the following table:

ENCLOSURES			
Location	Finish	Environment	NEMA 250 Type
Indoor	Finished	Dry	1
Indoor	Unfinished	Industrial Use	12
Outdoor	Any	Denoted “WP”	3R
Indoor and Outdoor	Any	Wet and/or Corrosive	4X: 304 Stainless Steel
Indoor and Outdoor	Any	Wet, Dust or Oil	13
Indoor and Outdoor	Any	Hazardous Gas	7
Indoor and Outdoor	Any	Hazardous Dust	9

PART 3 - EXECUTION

3.1 GENERAL

- A. Install equipment in accordance with manufacturer’s recommendations.

3.2 CONTROL DEVICES

- A. Unless otherwise shown, install heavy-duty, oil-tight type in nonhazardous, indoor, dry locations, including motor control centers, control panels, and individual stations.

- B. Unless otherwise shown, install heavy-duty, watertight and corrosion-resistant type in nonhazardous, outdoor, or normally wet areas.

3.3 SUPPORT AND FRAMING CHANNEL

- A. Install where required for mounting and supporting electrical equipment, raceway, and cable tray systems.
- B. Channel Type:
 - 1. Interior, Dry (Noncorrosive) Locations:
 - a. Steel Raceway: Pre-Galvanized steel or paint coated.
 - 2. Interior, Corrosive (Wet or Dry) Locations:
 - a. PVC-Coated Steel Conduit and Other Systems Not Covered: Stainless steel.
 - 3. Outdoor Locations:
 - a. PVC-Coated Steel Conduit and Other Systems Not Covered: Stainless steel.
- C. Paint cut ends prior to installation with the following:
 - 1. Carbon Steel Channel: Zinc-rich primer.
 - 2. Painted Channel: Rust-inhibiting epoxy or acrylic paint.
 - 3. Nonmetallic Channel: Epoxy resin sealer.
 - 4. PVC-Coated Channel: PVC patch.

3.4 FIRESTOPS

- A. Install in strict conformance with manufacturer's instructions. Comply with installation requirements established by testing and inspecting agency.
- B. Sealant: Install sealant, including forming, packing, and other accessory materials, to fill openings around electrical services penetrating floors and walls, to provide firestops with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs.

END OF SECTION 26 05 04

SECTION 26 05 05 – SELECTIVE DEMOLITION FOR ELECTRICAL

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. This Section describes general requirements and methods of execution relating to the demolition or portions of the electrical system for the Project.

1.2 DEMOLITION/REMODEL WORK

- A. The Contractor shall carefully examine the Drawings and Specifications, visit the site, and make note of all existing conditions, dimensions, and limitations prior to Bid and make allowances thereto.
- B. No Change Orders will be issued for Contractor 's failure to visit site, remodel work necessary for a complete installation of systems shown, and Contractor's lack of understanding of amount or difficulty of work involved.
- C. The Contractor shall also notify all corporations, companies, individuals or local authorities owning, or having jurisdiction over existing utilities and services which interfere in any manner with the execution of the Work under this Contract, and shall remove, relocate or protect such utilities or equipment as required by the parties having jurisdiction over same.
- D. If existing active or nonactive services (which may not be shown on Plans) are encountered that require relocation or disconnecting, the Contractor shall make written request for decision on proper handling of the services. The Contractor shall not proceed with the Work until so authorized by the Engineer.
- E. When areas of the existing buildings are adjacent to the area of construction in which work is going on and are occupied, then the Contractor shall arrange the Work so as to reduce to minimum the periods of interruption or outages in the various services.
- F. Not less than one week before any system is to be put out of service, the Contractor shall notify and coordinate with other trades and the Owner of such necessity including the extent of the Work to be done during the outage, possible length of Time required for that phase of the Work, and the desired time at which the outage is to begin.
- G. The Contractor shall balance additional loads to the existing circuitry between phases and furnish a revised, typed panel directory on existing panel boards where circuitry is changed.
- H. The Contractor shall carefully lay out all work in advance to minimize cutting, channeling, or drilling and where necessary, all cutting and patching shall be done in a manner approved by the Engineer. The Contractor shall not endanger the stability of any structure and will restore any damaged surfaces to original conditions at no cost to the Owner.

- I. The Contractor shall remove or relocate existing conduits, wires, equipment, devices, or fixtures indicated on Drawings and as required by remodel operations. Where the reuse of existing conduits, wires, devices, or fixture is permitted, the Contractor shall verify that wiring is continuous.
- J. Existing equipment which is indicated as being removed and not indicated for re-use shall be disposed of unless stated otherwise. All wire removed as part of demolition activities shall be returned to the City as directed.

END OF SECTION 26 05 05

SECTION 26 05 19 – CONDUCTORS AND COMMUNICATIONS CABLING

PART 1 - GENERAL

1.1 SUMMARY

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

1.2 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. ASTM International (ASTM):
 - a. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
 - b. B3, Standard Specification for Soft or Annealed Copper Wire.
 - c. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
 - d. B496, Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors.
 2. Insulated Cable Engineer's Association, Inc. (ICEA):
 - a. S-58-679, Standard for Control Cable Conductor Identification.
 - b. S-73-532, Standard for Control Thermocouple Extensions and Instrumentation Cables.
 - c. T-29-520, Conducting Vertical Cable Tray Flame Tests with Theoretical Heat Input of 210,000 Btu/hour.
 3. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - a. 48, Standard Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV Through 500 kV.
 - b. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
 - c. 404, Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500000 V.
 4. National Electrical Manufacturers' Association (NEMA):
 - a. CC 1, Electric Power Connectors for Substations.

- b. WC 57, Standard for Control, Thermocouple Extension, and Instrumentation Cables.
 - c. WC 70, Standard for Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
 - d. WC 71, Standard for Nonshielded Cables Rated 2001-5000 Volts for Use in the Distribution of Electric Energy.
 - e. WC 74, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.
5. National Fire Protection Association (NFPA):
- a. 70, National Electrical Code (NEC).
 - b. 262, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
6. Telecommunications Industry Association (TIA): TIA-568-C, Commercial Building Telecommunications Cabling Standard.
7. American National Standards Institute (ANSI)
- a. ANSI X3.166, Information Systems--Fiber Data Distributed Interface (FDDI)--Token Ring Physical Layer Medium Dependent (PMD)
8. Underwriters Laboratories Inc. (UL):
- a. 13, Standard for Safety for Power-Limited Circuit Cables.
 - b. 44, Standard for Safety for Thermoset-Insulated Wires and Cables.
 - c. 62, Standard for Safety for Flexible Cord and Cables.
 - d. 486A-486B, Standard for Safety for Wire Connectors.
 - e. 486C, Standard for Safety for Splicing Wire Connectors.
 - f. 510, Standard for Safety for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.
 - g. 854, Standard for Safety for Service-Entrance Cables.
 - h. 1277, Standard for Safety for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
 - i. 1569, Standard for Safety for Metal-Clad Cables.
 - j. 1581, Standard for Safety for Reference Standard for Electrical Wires, Cables, and Flexible Cords.
 - k. 1072, Standard for Safety for Medium-Voltage Power Cables.

1.3 SUBMITTALS

- A. Furnish in accordance with Project Specifications.
- B. Action Submittals:
 - 1. Product Data:
 - a. Wire and cable.
 - b. Wire and cable accessories.
 - c. Fiber optic data cable

1.4 QUALITY ASSURANCE

- A. Authority Having Jurisdiction (AHJ):
 - 1. Provide the Work in accordance with NFPA 70. Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
 - 2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories Inc. shall conform to those standards and shall have an applied UL listing mark.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers complying with the Quality Assurance requirements are acceptable.

2.2 CONDUCTORS AND CABLES 600 VOLTS AND BELOW

- A. General:
 - 1. Provide conductor and cable suitable for the temperature, conditions and location where installed.
 - 2. Permanently and legibly marked with manufacturer's name, maximum working voltage for which cable was tested, type of cable, and UL listing mark.
 - 3. Suitable for installation in open air, in cable trays, or conduit.
 - 4. Minimum Temperature Rating: 90 degrees C dry locations, 75 degrees C wet locations.
 - 5. Overall Outer Jacket: PVC, flame-retardant, sunlight- and oil-resistant.
- B. Power Conductors: All conductors to be stranded.
- C. Control Conductors: Provide stranded conductors.

- D. Conductor Material: Copper for all wires and cables. Aluminum conductors are not acceptable.
- E. Insulation: Provide THHN/THWN insulation for all interior conductors. For all exterior applications, provide XHHW insulation. Type XHHW insulation shall be used for all conductors in exterior underground raceways.
- F. Color coding for phase identification in accordance with Section 26 05 00 – General Requirements for Electrical Work.
- G. VFD Cables: Provide VFD cable for all VFD applications.
 - 1. Cable shall contain all phase conductors plus ground.
 - 2. Contain a braided shield with 85% coverage and foil shield with 100% coverage.
 - 3. Insulation to be XLPE.
 - 4. For retrofit applications where conduit fill is limited, modifications to the above requirements to reduce cable size may be required. Submit product for review and approval by Engineer.
- H. Flexible Cords and Cables:
 - 1. Type SOW-A/50 with ethylene propylene rubber insulation in accordance with UL 62.
 - 2. Conform to physical and minimum thickness requirements of NEMA WC 70.
- I. Type 1, Multiconductor Control Cable:
 - 1. Conductors:
 - a. 14 AWG, seven-strand copper.
 - b. Insulation: 15-mil PVC with 4-mil nylon.
 - c. UL 1581 listed as Type THHN/THWN rated VW-1.
 - d. Conductor group bound with spiral wrap of barrier tape.
 - e. Color Code: In accordance with ICEA S-58-679, Method 1, Table 2.
 - 2. Cable: Passes the ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.

3. Cable Sizes:

No. of Conductors	Max. Outside Diameter (Inches)	Jacket Thickness (Mils)
3	0.41	45
5	0.48	45
7	0.52	45
12	0.72	60
19	0.83	60
25	1.00	60
37	1.15	80

J. Type 3, 16 AWG, Twisted, Shielded Pair, Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57 requirements.

1. Outer Jacket: 45-mil nominal thickness.
2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
3. Dimension: 0.31-inch nominal OD.
4. Conductors:
 - a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
 - b. 20 AWG, seven-strand tinned copper drain wire.
 - c. Insulation: 15-mil nominal PVC.
 - d. Jacket: 4-mil nominal nylon.
 - e. Color Code: Pair conductors, black and red.

K. Type 4, 16 AWG, Twisted, Shielded Triad Instrumentation Cable: Single triad, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57 requirements.

1. Outer Jacket: 45-mil nominal.
2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage.
3. Dimension: 0.32-inch nominal OD.
4. Conductors:
 - a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.

- b. 20 AWG, seven-strand, tinned copper drain wire.
 - c. Insulation: 15-mil nominal PVC.
 - d. Jacket: 4-mil nylon.
 - e. Color Code: Triad conductors black, red, and blue.
- L. Type 5, 18 AWG, Multitwisted Shielded Pairs, with a Common Overall Shield, Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable, meeting NEMA WC 57 requirements.
- 1. Conductors:
 - a. Bare soft annealed copper, Class B, seven-strand concentric, in accordance with ASTM B8.
 - b. Tinned copper drain wires.
 - c. Pair drain wire size AWG 20, group drain wire size AWG 18.
 - d. Insulation: 15-mil PVC.
 - e. Jacket: 4-mil nylon.
 - f. Color Code: Pair conductors, black and red with red conductor numerically printed for group identification.
 - g. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer.
 - 2. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.
 - 3. Cable Sizes:

Number of Pairs	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
4	0.50	45
8	0.68	60
12	0.82	60
16	0.95	80
24	1.16	80
36	1.33	80
50	1.56	80

- M. Type 8, Multiconductor Adjustable Frequency Drive Power Cable:
- 1. Conductors:
 - a. Class B, stranded coated copper.

- b. Insulation: 600-volt cross-linked polyethylene, UL Type XHHW-2.
- c. Grounding Conductors: Insulated stranded copper.
- 2. Sheath:
 - a. UL 1277 Type TC, 90 degrees C.
 - b. Continuous shield, Al/polyester foil, drain wires, overall copper braid.
- 3. Outer Jacket: Polyvinyl chloride (PVC) per UL 1569.
- 4. Cable Sizes:

Conductor Size	Minimum Ground Wire Size (AWG)	No. of Insulated Conductors	Max. Outside Diameter (Inches)	Minimum Jacket Thickness (Mils)
12 AWG	12	4	0.655	50
10 AWG	10	4	0.769	50
8 AWG	8	4	0.940	50
6 AWG	6	4	1.038	50
4 AWG	4	4	1.180	50
2 AWG	2	4	1.351	50

2.3 300-VOLT RATED CABLE

- A. General:
 - 1. Type PLTC, meeting requirements of UL 13 and NFPA 70, Article 725.
 - 2. Permanently and legibly marked with manufacturer’s name, maximum working voltage for which cable was tested, type of cable, and UL listing mark.
 - 3. Suitable for installation in open air, in cable trays, or conduit.
 - 4. Minimum Temperature Rating: 105 degrees C.
 - 5. Passes Vertical Tray Flame Test.
 - 6. Outer Jacket: PVC, flame-retardant, sunlight- and oil-resistant.
- B. Type 24, Twisted Pair Fire Alarm Cable, Shielded: Power limited fire protective signaling circuit cable meeting requirements of NFPA 70, Article 760.
 - 1. Cable: Pass NFPA 262, 70,000 Btu flame test and listed by State Fire Marshall.
 - 2. Outer Jacket: Red in color, identified along its entire length as fire protective signaling circuit cable.
 - 3. Conductors:

- a. Solid, tinned, or bare copper shielded, with stranded tinned copper drain wire.
 - b. Insulation: 15-mil PVC.
4. Cable Sizes:

Wire Size	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Inches)
12	0.36	0.042
14	0.32	0.042
16	0.26	0.037
18	0.23	0.037

2.4 SPECIAL CABLES

- A. Type 30, Foil Shielded/Unshielded Twisted Pair (F/UTP) Telephone and Data Cable, 300V:
 - 1. Category 6A, UL listed, and third party verified to comply with TIA/EIA 568-C.2 Category 6A requirements.
 - 2. Suitable for high speed network applications including gigabit ethernet and video. Cable shall be interoperable with other standards compliant products and shall be backward compatible with Category 5 and Category 5e.
 - 3. Four each individually twisted pair, 23 AWG conductors, with polyolefin insulation and blue PVC jacket.
 - 4. Outer foil screen with 26 AWG tinned copper shield drain wire.
 - 5. NEC/UL Riser (CMR) rated.
 - 6. Cable shall withstand a bend radius of 1.2-inch minimum at a temperature of minus 10 degrees C maximum without jacket or insulation cracking.
 - 7. Manufacturer and Product: Belden; 10GX62F or approved equal.
- B. Multimode Fiber-Optic Cable:
 - 1. 24-count fiber cable.
 - 2. Outdoor/indoor; Riser Rated (OFNR).
 - 3. Tight buffered.
 - 4. Fibers and buffer tubes shall be color coded with distinct and recognizable colors in accordance with EIA/TIA-598.
 - 5. Jacket: Flame retardant, UV resistant, black.
 - 6. Type:

- a. Approvals and Listings: NEC OFNR, CSA FT-4, ICEA S104-696.
- b. Fiber Type: Multimode
- c. Nominal Cable Outer Diameter: 0.31 in.
- d. Core Diameter: 50 μm
- e. Fiber Category: OM3
- f. Wavelengths: 850 nm/1300 nm
- g. Maximum Attenuation: 2.8 dB/km / 1.0 dB/km
- h. Operating Temperature Range: -40 to +70 Deg C
- i. Max Tensile Loading: 300/90 lbf (Installation/Operation)
- j. Minimum Cable Bending Radius: 4.7/3.1 inches (Installation/Operation).

7. Manufacturers:

- a. Corning Cable Systems, Corning FREEDM One (024T8F-31180-29) or equivalent.

2.5 GROUNDING CONDUCTORS

- A. Equipment: Stranded copper with green, Type USE/RHH/RHW-XLPE or THHN/THWN, insulation.
- B. Direct Buried: Bare stranded copper.

2.6 ACCESSORIES FOR CONDUCTORS 600 VOLTS AND BELOW AND FIBER OPTICS

A. Tape:

1. General Purpose, Flame Retardant: 7-mil, vinyl plastic, Scotch Brand 33+, rated for 90 degrees C minimum, meeting requirements of UL 510.
2. Flame Retardant, Cold and Weather Resistant: 8.5-mil, vinyl plastic, Scotch Brand 88.
3. Arc and Fireproofing:
 - a. 30-mil, elastomer.
 - b. Manufacturers and Products:
 - 1) 3M; Scotch Brand 77, with Scotch Brand 69 glass cloth tapebinder.
 - 2) Plymouth; 53 Plyarc, with 77 Plyglas glass cloth tapebinder.
 - 3) Approved equal.

B. Identification Devices:

1. Sleeve:
 - a. Permanent, PVC, yellow or white, with legible machine-printed black markings.
 - b. Manufacturers and Products:
 - 1) Raychem; Type D-SCE or ZH-SCE.
 - 2) Brady, Type 3PS.
 - 3) Approved equal.
 2. Heat Bond Marker:
 - a. Transparent thermoplastic heat bonding film with acrylic pressure sensitive adhesive.
 - b. Self-laminating protective shield over text.
 - c. Machine printed black text.
 - d. Manufacturer and Product: 3M Co.; Type SCS-HB or approved equal.
 3. Marker Plate: Nylon, with legible designations permanently hot stamped on plate.
 4. Tie-On Cable Marker Tags:
 - a. Chemical-resistant white tag.
 - b. Size: 1/2 inch by 2 inches.
 - c. Manufacturer and Product: Raychem; Type CM-SCE or approved equal.
 5. Grounding Conductor: Permanent green heat-shrink sleeve, 2-inch minimum.
- C. Connectors for conductors
1. Provide UL-listed factory-fabricated, solderless metal connectors of sizes, ampacity ratings, materials, types and classes for applications and for services indicated. Use connectors with temperature ratings equal to or greater than those of the wires upon which used.
 - a. For wire sizes #8 and smaller: insulated pressure type (with live spring) rated 105°C, 600V, for building wire and 1000V in fixtures,
 - 1) Manufacturers and Products:
 - a) Scotchlock
 - b) Ideal.
 - c) Approved equal
 - b. For wire sizes #6 AWG and larger: Insulated cable connector block NSI Tork, or equivalent abrasion and chemical resistant type.

D. Connectors and Terminations:

1. Nylon, Self-Insulated Crimp Connectors:
 - a. Manufacturers and Products:
 - 1) Thomas & Betts; Sta-Kon.
 - 2) Burndy; Insulug.
 - 3) ILSCO.
 - 4) Approved equal
2. Nylon, Self-Insulated, Crimp Locking-Fork, Torque-Type Terminator:
 - a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
 - b. Seamless.
 - c. Manufacturers and Products:
 - 1) Thomas & Betts; Sta-Kon.
 - 2) Burndy; Insulink.
 - 3) ILSCO; ILSCONS.
 - 4) Approved equal
3. Self-Insulated, Freespring Wire Connector (Wire Nuts):
 - a. UL 486C.
 - b. Plated steel, square wire springs.
 - c. Manufacturers and Products:
 - 1) Thomas & Betts.
 - 2) Ideal; Twister.
 - 3) Approved equal.
4. Self-Insulated, Set Screw Wire Connector:
 - a. Two piece compression type with set screw in brass barrel.
 - b. Insulated by insulator cap screwed over brass barrel.
 - c. Manufacturers:
 - 1) 3M Co.
 - 2) Thomas & Betts.
 - 3) Marrette.

- 4) Approved equal.

E. Cable Lugs:

1. In accordance with NEMA CC 1.
2. Rated 600 volts of same material as conductor metal.
3. Uninsulated Crimp Connectors and Terminators:
 - a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
 - b. Manufacturers and Products:
 - 1) Thomas & Betts; Color-Keyed.
 - 2) Burndy; Hydent.
 - 3) ILSCO.
 - 4) Approved equal.
4. Uninsulated, Bolted, Two-Way Connectors and Terminators:
 - a. Manufacturers and Products:
 - 1) Thomas & Betts; Locktite.
 - 2) Burndy; Quiklug.
 - 3) ILSCO.
 - 4) Approved equal.

F. Cable Ties:

1. Nylon, adjustable, self-locking, and reusable.
2. Manufacturer and Product: Thomas & Betts; TY-RAP or approved equal.

G. Heat Shrinkable Insulation:

1. Thermally stabilized cross-linked polyolefin.
2. Single wall for insulation and strain relief.
3. Dual Wall, adhesive sealant lined, for sealing and corrosion resistance.
4. Manufacturers and Products:
 - a. Thomas & Betts; SHRINK-KON.
 - b. Raychem; RNF-100 and ES-2000.
 - c. Approved equal.

- H. F/UTP cable:
 - 1. Provide terminators, connectors, and junctions necessary for a complete Ethernet/IP system.
- I. Fiber optics:
 - 1. Provide markers for labeling each end of a fiber optic cable.
 - 2. Provide markers for individual fiber optic strands, jumpers, and patch cables. Attach to fiber using tie wrap or other approved method of securing the marker.
 - 3. Markers must have space for typed or machine printed text.
 - 4. Terminations: Per Manufacturer Recommendations.
 - 5. Innerduct:
 - a. Smooth walled polyethylene tube to protect fiber optic cable.
 - b. Install innerduct in conduit.
 - c. Install fiber optic cable in innerduct.
 - d. Manufacturers: Carlon, or equal.
 - 6. Split Duct:
 - a. At patch panels and pull boxes provide smooth walled polyethylene split innerduct to bridge gap between panel and end of conduit.

2.7 ACCESSORIES FOR CONDUCTORS ABOVE 600 VOLTS

- A. Molded Splice Kits:
 - 1. Components necessary to provide insulation, metallic shielding and grounding systems, and overall jacket.
 - 2. Capable of making splices with a current rating equal to, or greater than cable ampacity, conforming to IEEE 404.
 - 3. Class 5kV, with compression connector, EPDM molded semiconductive insert, peroxide-cured EPDM insulation, and EPDM molded semiconductive outer shield.
 - 4. Premolded splice shall be re-jacketed with a heat shrinkable adhesive-lined sleeve to provide a waterproof seal.
 - 5. Manufacturers:
 - a. Elastimold.
 - b. Cooper Industries.
 - c. Approved equal.
- B. Heat Shrinkable Splice Kits:

1. Components necessary to provide insulation, metallic shielding and grounding systems, and overall jacket.
 2. Capable of making splices with a current rating equal to, or greater than, cable ampacity, conforming to IEEE 404.
 3. Class 5kV, with compression connector, splice insulating and conducting sleeves, stress-relief materials, shielding braid and mesh, and abrasion-resistant heat shrinkable adhesive-lined re-jacketing sleeve to provide a waterproof seal.
 4. Manufacturers:
 - a. Raychem.
 - b. 3M Co.
 - c. Approved equal.
- C. Termination Kits:
1. Capable of terminating 5kV, single-conductor, polymeric-insulated shielded cables plus a watertight shield ground clamp. Provide spade lug or rod-type connectors as required.
 2. Capable of producing a termination with a current rating equal to, or greater than, cable ampacity meeting Class 1 requirements of IEEE 48.
 3. Capable of accommodating cable shielding or construction without need for special adapters or accessories.
 4. Manufacturers:
 - a. Raychem.
 - b. 3M Co.
 - c. Approved equal.
- D. Bus Connection Insulation:
1. Heat shrinkable tubing, tape, and sheets of flexible cross-linked polymeric material formulated for high dielectric strength.
 2. Tape and sheet products to have coating to prevent adhesion to metal surfaces.
 3. Manufacturer: Raychem or approved equal.
- E. Cable Lugs:
1. In accordance with NEMA CC1.
 2. Rated 5kV of same material as conductor metal.
 3. Manufacturers and Products, Uninsulated Compression Connectors and Terminators:

- a. Burndy; Hydent.
 - b. Thomas & Betts; Color-Keyed.
 - c. ILSCO.
 - d. Approved equal.
4. Manufacturers and Products, Uninsulated, Bolted, Two-Way Connectors and Terminators:
- a. Thomas & Betts; Locktite.
 - b. ILSCO.
 - c. Approved equal.

2.8 PULLING COMPOUND

- A. Nontoxic, noncorrosive, noncombustible, nonflammable, water-based lubricant; UL listed.
- B. Suitable for rubber, neoprene, PVC, polyethylene, hypalon, CPE, and lead-covered wire and cable.
- C. Approved for intended use by cable manufacturer.
- D. Suitable for zinc-coated steel, aluminum, PVC, bituminized fiber, and fiberglass raceways.
- E. Manufacturers:
 1. Ideal Co.
 2. Polywater, Inc.
 3. Cable Grip Co.
 4. Approved equal.

2.9 WARNING TAPE

- A. As specified in Section 26 05 33 – Raceway and Boxes.

PART 3 - EXECUTION

3.1 WIRING METHOD

- A. Use the following wiring methods as indicated:
 1. Wire: Install all wire in raceway, minimum size for light and power circuits shall be #12 AWG. Minimum size for control wire shall be 14 AWG.

3.2 INSTALLATION OF WIRES AND CABLES

- A. General: Install electrical cables, wires, and connectors in compliance with NEC and manufacturer's recommendations.

- B. Pull conductors simultaneously where more than one is being installed in same raceway. Use UL listed pulling compound or lubricant, where necessary.
- C. Do not exceed cable manufacturer's recommendations for maximum pulling tensions and minimum bending radii. Install splice and tap connectors which possess equivalent or better mechanical strength and insulation rating than conductors being spliced. No joints or taps permitted in service or feeder circuits.
- D. Tighten electrical connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A.
- E. Cable Lugs: Provide with correct number of holes, bolt size, and center-to-center spacing as required by equipment terminals.
- F. Bundling: Where single conductors and cables in manholes, handholes, vaults, cable trays, and other indicated locations are not wrapped together by some other means, bundle conductors from each conduit throughout their exposed length with cable ties placed at intervals not exceeding 12 inches on center.
- G. Ream, remove burrs, and clear interior of installed conduit before pulling wires or cables.
- H. Concrete-Encased Raceway Installation: Prior to installation of conductors, pull through each raceway a mandrel approximately 1/4 inch smaller than raceway inside diameter.
- I. VFD Wiring: Shielded power cables shall be used for load-side circuits between VFD's and motors. Install VFD cables per VFD manufacturer requirements. VFD cable shielding must be connected at both the drive and the motor ends unless the drive manufacturer provided different guidelines. The shielding must be connected at a 360° contact.

3.3 CIRCUIT IDENTIFICATION

- A. Identify power, instrumentation, and control conductor circuits and neutral wires at each termination, and in accessible locations such as manholes, handholes, panels, switchboards, motor control centers, pull boxes, and terminal boxes.
- B. Circuit Schedules: Identify using circuit schedule designations as specified in Section 26 05 00 – General Requirements for Electrical Work.
- C. Method:
 - 1. Conductors 3 AWG and Smaller: Identify with sleeves or heat bond markers.
 - 2. Cables and Conductors 2 AWG and Larger:
 - a. Identify with marker plates or tie-on cable marker tags.
 - b. Attach with nylon tie cord.
 - 3. Taped-on markers or tags relying on adhesives not permitted.

3.4 CONDUCTORS 600 VOLTS AND BELOW

- A. Install 10 AWG or 12 AWG conductors for branch circuit power wiring in lighting and receptacle circuits.
- B. Do not splice incoming service conductors and branch power distribution conductors 6 AWG and larger, unless specifically indicated or approved by Engineer.
- C. Connections and Terminations:
 - 1. Install wire nuts only on solid conductors. Wire nuts are not allowed on stranded conductors.
 - 2. Install nylon self-insulated crimp connectors and terminators for instrumentation and control, circuit conductors.
 - 3. Install self-insulated, set screw wire connectors for two-way connection of power circuit conductors 12 AWG and smaller.
 - 4. Install uninsulated crimp connectors and terminators for instrumentation, control, and power circuit conductors 4 AWG through 2/0 AWG.
 - 5. Install uninsulated, bolted, two-way connectors and terminators for power circuit conductors 3/0 AWG and larger.
 - 6. Install uninsulated terminators bolted together on motor circuit conductors 10 AWG and larger.
 - 7. Place no more than one conductor in any single-barrel pressure connection.
 - 8. Install crimp connectors with tools approved by connector manufacturer.
 - 9. Install terminals and connectors acceptable for type of material used.
 - 10. Compression Lugs:
 - a. Attach with a tool specifically designed for purpose. Tool shall provide complete, controlled crimp and shall not release until crimp is complete.
 - b. Do not use plier type crimpers.
- D. Do not use soldered mechanical joints.
- E. Splices and Terminations:
 - 1. Insulate uninsulated connections.
 - 2. Indoors: Use general purpose, flame retardant tape or single wall heat shrink.
 - 3. Outdoors, Dry Locations: Use flame retardant, cold- and weather-resistant tape or single wall heat shrink.
 - 4. Below Grade and Wet or Damp Locations: Use dual wall heat shrink.
- F. Cap spare conductors with UL listed end caps.

- G. Cabinets, Panels, and Motor Control Centers:
 - 1. Remove surplus wire, braid and secure.
 - 2. Where conductors pass through openings or over edges in sheet metal, remove burrs, chamfer edges, and install bushings and protective strips of insulating material to protect the conductors.

- H. Control and Instrumentation Wiring:
 - 1. Where terminals provided will accept such lugs, terminate control and instrumentation wiring, except solid thermocouple leads, with insulated, locking-fork compression lugs.
 - 2. Terminate with methods consistent with terminals provided, and in accordance with terminal manufacturer's instructions.
 - 3. Locate splices in readily accessible cabinets or junction boxes using terminal strips.
 - 4. Where connections of cables installed under this section are to be made to instrumentation and controls equipment leave pigtails of adequate length for bundled connections.
 - 5. Cable Protection:
 - a. Under Infinite Access Floors: May install without bundling.
 - b. All Other Areas: Install individual wires, pairs, or triads in flex conduit under floor or grouped into bundles at least 1/2 inch in diameter.
 - c. Maintain integrity of shielding of instrumentation cables.
 - d. Ensure grounds do not occur because of damage to jacket over shield.

- I. Extra Conductor Length: For conductors to be connected by others, install minimum 6 feet of extra conductor in freestanding panels and minimum 2 feet in other assemblies.

3.5 FIBER OPTIC CABLE:

- A. Innerduct:
 - 1. Install in accordance with manufacturer's recommendation.
 - 2. Use single unjoined lengths from one handhole or pull point to the next.
 - 3. End innerduct at manholes or pull points.
 - 4. One fiber optic cable per innerduct, maximum.

- B. Fiber Optic Cable:
 - 1. Install cables in innerduct.
 - 2. Provide lengths required to perform installations as indicated on Drawings.

3. Install cable directly from shipping reels. Ensure cable is not:
 - a. Dented, nicked, or kinked.
 - b. Subjected to pull stress greater than or bend radius less than manufacturers specification.
 - c. Otherwise subjected to treatment which may damage fiber strands during installation.
4. Splices: None. Install cables in unspliced lengths between fiber patch panels.
5. Terminate at fiber patch panel:
 - a. Fan out fiber cable to allow direct connectorization of fiber optic cable.
 - b. Sleeve over individual fiber with Kevlar reinforced furcation tubes.
 - c. At point of convergence of furcation tubes, provide strain relief with high density plastic fan-out collar.
 - d. Terminate all fibers.
- C. Contractor shall use zip-cord jumper cables between patch/breakout panels and communications equipment.
- D. Test with optical time domain reflectometer (OTDR) prior to installation and after installation. Test Polarization Mode Dispersion (PMD) and Fiber Distributed Data Interface (FDDI) requirements for the following:
 1. Transmit power levels
 2. AC extinction ratio
 3. Optical wave shape
 4. Duty cycle distortion
 5. Data dependent jitter
 6. Random jitter
 7. Transmit frequency
 8. Minimum optical input
 9. Receiver jitter tolerance
- E. Pre-installation tests:
 1. Perform acceptance tests on the cable prior to installation to verify that the cable conforms to the manufacturer's specifications, and is free of defects, breaks and damages by transportation and manufacturing processes. Perform tests on all reels of cable. Cable shall not be installed until the Engineer has reviewed the test report.

2. Verify continuity and attenuation or loss for each fiber on each reel and document results of physical inspections to identify any cable and reel damage conditions, and any deviations from the manufacturer's specifications.
3. Document test results and submit the report to the Engineer for review.

F. Post-Installation Tests:

1. Conduct the following tests on each fiber in the cable segment. Tests shall be conducted at both 850 and 1300 nm. No splice loss shall have a loss of 0.15 dB or greater with fiber attenuation measured in dB/km.
2. Measure the attenuation of each optical fiber in both directions using a with an Optical Loss Test Set (OLTS) at both 850 nm and 1300 nm. Test shall be conducted per TIA/EIA 526-7. Provide a reference power level measured with a patch cord and connectors of the same types used on the fiber cable. Measure and record the reference power level of the Laser Light Source. Measure and record the received power level of each optical. Repeat the same measurements in the other direction.
3. Pigtail splices shall have a loss no greater than 0.15 dB, as determined by either a Profile Alignment System (PAS) or Light Injection (LID) splice loss estimate, at the time the splice is made. Splices with an optical loss of greater than 0.15 dB shall be redone. OTDR traces at both 1310 nm and 1550 nm wavelengths display no unexplained losses, reflectance events, or other discontinuities.
4. Test Documentation:
 - a. Hard copy of OTDR plots.
 - b. Results of bi-directional test with power meter and light source.
 - c. Provide an updated version of the light budget spreadsheet including actual cable lengths used, and actual losses measured by tests.

- G. The Owner shall be notified a minimum of 5 days prior to tests and reserve the right to witness field tests.

3.6 FIELD QUALITY CONTROL

- A. Prior to energizing, test wires and cables for electrical continuity and for short-circuits.

END OF SECTION 26 05 19

SECTION 26 05 26 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. This section includes grounding requirements for electrical systems including conductors, connectors and electrodes.

1.2 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
 - 1. Institute of Electrical and Electronics Engineers (IEEE): C2, National Electrical Safety Code (NESC).
 - 2. National Fire Protection Association (NFPA): 70, National Electrical Code. (NEC).

1.3 SUBMITTALS

- A. Furnish submittals in accordance with Project Specifications.
- B. Action Submittals:
 - 1. Shop Drawings:
 - a. Product data for the following:
 - 1) Exothermic weld connectors.
 - 2) Mechanical connectors.
 - 3) Compression connectors.
 - 4) Specialty tools.
 - 5) Ground rods.

1.4 QUALITY ASSURANCE

- A. Comply with section 26 05 00 – General Requirements for Electrical Work.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
 - 1. Comply with UL 467.
- C. Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products may be incorporated into the Work and are not limited.

2.2 GROUNDING CONDUCTORS

- A. For insulated conductors, comply with Section 26 05 19 – Conductors and Communications Cabling.
- B. Material: Copper.
- C. Equipment Grounding Conductors: Insulated with green-colored insulation.
- D. Isolated Ground Conductors: Insulated with green-colored insulation with yellow stripe. On feeders with isolated ground, use colored tape, alternating bands of green and yellow tape to provide a minimum of three bands of green and two bands of yellow.
- E. Grounding Electrode Conductors: Stranded cable.
- F. Underground Conductors: Bare, tinned, stranded, unless otherwise indicated.
- G. Bare Copper Conductors: Comply with the following:
 - 1. Solid Conductors: ASTM B 3.
 - 2. Assembly of Stranded Conductors: ASTM B 8.
- H. Copper Bonding Conductors: As follows:
 - 1. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG copper conductor, 1/4-inch in diameter.
 - 2. Bonding Conductor: No. 4 or No. 6 AWG, stranded copper conductor.
 - 3. Bonding Jumper: Bare copper tape, braided bare copper conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16-inch thick.
 - 4. Tinned Bonding Jumper: Tinned-copper tape, braided copper conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
- I. Grounding Bus: Bare, annealed copper bars of rectangular cross section, with insulators.

2.3 CONNECTOR PRODUCTS

- A. Comply with IEEE 837 and UL 467; listed for use for specific types, sizes, and combinations of conductors and connected items.
- B. Mechanical Type: Bolted-pressure-type connectors, Split-bolt, saddle, or cone screw type; copper alloy material.

- C. Compression Type:
 - 1. Compress-deforming type; wrought copper extrusion material.
 - 2. Single indentation for conductors 6 AWG and smaller.
 - 3. Double indentation with extended barrel for conductors 4 AWG and larger.
 - 4. Barrels prefilled with oxide-inhibiting and antiseizing compound and sealed.
- D. Welded Connectors: Exothermic-welded type, in kit form, and selected per manufacturer's written instructions.
 - 1. Outdoor Weld: Suitable for exposure to elements or direct burial.
 - 2. Indoor Weld: Utilize low-smoke, low-emission process.

2.4 GROUNDING ELECTRODES

- A. Ground Rods: Sectional type; copper-clad steel.
 - 1. Size: 5/8 inch in diameter by 8-feet in length.

PART 3 - EXECUTION

3.1 APPLICATION

- A. In raceways, use insulated equipment grounding conductors.
- B. Exothermic-Welded Connections: Use for connections to structural steel and for underground connections, except those at test wells.
- C. Equipment Grounding Conductor Terminations: Use bolted pressure clamps.
- D. Ground Rod Clamps at Test Wells: Use bolted pressure clamps with at least two bolts.
- E. Underground Grounding Conductors: Use copper conductor, No. 2/0 AWG minimum. Bury at least 24 inches below grade or bury 12 inches above duct bank when installed as part of the duct bank.
- F. Ground electrical service neutral at service entrance equipment with grounding electrode conductor to grounding electrode system.
- G. Ground each separately derived system neutral with common grounding electrode conductor to grounding electrode system.
- H. Bond together all grounding electrodes that are present at each building or structure served to form one common grounding electrode system.
- I. Shielded Power Cables: Ground shields at each splice or termination in accordance with recommendations of splice or termination manufacturer.

J. Shielded Instrumentation Cables:

1. Ground shield to ground bus at power supply for analog signal.
2. Expose shield minimum 1 inch at termination to field instrument and apply heat shrink tube.
3. Do not ground instrumentation cable shield at more than one point.

3.2 EQUIPMENT GROUNDING CONDUCTORS

- A. Comply with NFPA 70, Article 250, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by NFPA 70 are indicated.
- B. Install equipment grounding conductors in all feeders and circuits.
- C. Install insulated equipment grounding conductor with circuit conductors for the following items, in addition to those required by NEC:
1. Feeders and branch circuits.
 2. Lighting circuits.
 3. Receptacle circuits.
 4. Single-phase motor and appliance branch circuits.
 5. Three-phase motor and appliance branch circuits.
 6. Flexible raceway runs.
 7. Armored and metal-clad cable runs.
- D. Nonmetallic Raceways: Install an equipment grounding conductor in nonmetallic raceways unless they are designated for telephone or data cables.
- E. Air-Duct Equipment Circuits: Install an equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners and heaters. Bond conductor to each unit and to air duct.
- F. Water Heater: Bond conductor to heater units, piping, connected equipment, and components.
- G. Signal and Communication Systems: Provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.

- H. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-2-by-12-inch grounding bus.
 - 1. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.
- I. Motors Less Than 10 hp: Use furnished ground lug in motor connection box; if none furnished, provide compression, spade-type terminal connected to conduit box mounting screw.
- J. Motors 10 hp and Above: Use furnished ground lug in motor connection box; if none furnished, tap motor frame or equipment housing; furnish compression, one-hole, lug type terminal connected with minimum 5/16-inch brass threaded stud with bolt and washer.
- K. Circuits 20 Amps or Above: Tap motor frame or equipment housing; install solderless terminal with minimum 5/16-inch diameter bolt.

3.3 INSTALLATION

- A. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NEC. If concrete foundation is less than 20 feet long, coil excess conductor within the base of the foundation. Bond grounding conductor by cadweld process to reinforce steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to a grounding electrode external to concrete.
- B. Ground Rods: Install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes.
 - 1. Drive ground rods until tops are 6 inches below finished floor or final grade, unless otherwise indicated.
 - 2. Interconnect ground rods with grounding electrode conductors. Use exothermic welds, except at test wells and as otherwise indicated. Make connections without exposing steel or damaging copper coating.
- C. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- D. Bonding Straps and Jumpers: Install so vibration by equipment mounted on vibration isolation hangers and supports is not transmitted to rigidly mounted equipment. Use exothermic-welded connectors for outdoor locations, unless a disconnect-type connection is required; then, use a bolted clamp. Bond straps directly to the basic structure taking care not to penetrate any adjacent parts. Install straps only in locations accessible for maintenance.

- E. Metal Water Service Pipe: Provide insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes by grounding clamp connectors. Where a dielectric main water fitting is installed, connect grounding conductor to street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
- F. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with grounding clamp connectors.
- G. Bond interior metal piping systems and metal air ducts to equipment grounding conductors of associated pumps, fans, blowers, electric heaters, and air cleaners. Use braided-type bonding straps.
- H. Bond each aboveground portion of gas piping system upstream from equipment shutoff valve.

3.4 CONNECTIONS

- A. General: Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
 - 1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.
 - 2. Make connections with clean, bare metal at points of contact.
 - 3. Notify Engineer prior to backfilling ground connections.
- B. Exothermic-Welded Connections: Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.
 - 1. Wire brush or file contact point to bare metal surface.
 - 2. Use welding cartridges and molds in accordance with manufacturer's recommendations.
 - 3. Avoid using badly worn molds.
 - 4. Mold to be completely filled with metal when making welds.
 - 5. After completed welds have cooled, brush slag from weld area and thoroughly clean joint.
- C. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.

- D. Noncontact Metal Raceway Terminations: If metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically noncontinuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.
- E. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- F. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.
- G. Terminate ground and shield for VFD cables per VFD manufacturer requirements. VFD cable shielding must be connected at both the drive and the motor ends unless the drive manufacturer provided different guidelines. The shielding must be connected at a 360° contact. Provide and install cable clamps or metal fittings as required for proper connection.

3.5 METAL STRUCTURE GROUNDING

- A. Bond metal sheathing and exposed metal vertical structural elements to grounding system.
- B. Bond electrical equipment supported by metal platforms to the platforms.
- C. Provide electrical contact between metal frames and railings supporting pushbutton stations, receptacles, and instrument cabinets, and raceways carrying circuits to these devices.

3.6 MANHOLE AND HANDHOLE GROUNDING

- A. Install one ground rod inside each manhole and handhole larger than 24-inch by 24-inch inside dimensions.
- B. Ground Rod Floor Protrusion: 4 inches to 6 inches above floor.
- C. Make connections of grounding conductors fully visible and accessible.
- D. Connect all noncurrent-carrying metal parts, and any metallic raceway grounding bushings to ground rod with 6 AWG copper conductor.

3.7 TRANSFORMER GROUNDING

- A. Bond neutrals of transformers within buildings to system ground network, and to any additional indicated grounding electrodes.
- B. Bond neutrals of pad-mounted transformers to utility provided grounding electrode system. Coordinate with electric utility.

3.8 SURGE PROTECTION EQUIPMENT GROUNDING

- A. Connect surge arrestor ground terminals to equipment ground bus.

3.9 FIELD QUALITY CONTROL

- A. Test ground resistance of entire system and at each building/structure where electrical equipment is installed.
- B. Where maximum allowable ground resistance of 5 ohms is exceeded, install additional grounding mats or ground rods until ground resistance is equal to or below maximum allowable ground resistance.

END OF SECTION 26 05 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.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers complying with the Quality Assurance requirements are acceptable.
- B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
- C. Manufacturers: Subject to compliance with requirements, provide products by the following or equal:
 - 1. Thomas & Betts.
 - 2. Power-Strut.
 - 3. Unistrut.
 - 4. Cooper B-Line.
 - 5. Robroy.
 - 6. Aickinstrut.
 - 7. Approved equal.

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 stainless steel.

2.3 SUPPORTING DEVICES

- A. Channel and angle support systems, hangers, anchors, sleeves, brackets, fabricated items, and fasteners are designed to provide secure support from the building structure for electrical components.
 - 1. Material: Steel, hot-dip galvanized with G90 coating in accordance with ASTM A 525, or stainless steel.
 - 2. Support Channel Bolts, Nuts, and Washers: Stainless steel.

3. Metal Items for Use Outdoors or in Damp Locations: Stainless steel, except as otherwise indicated.
- B. Steel channel supports have 9/16-inch diameter holes at a maximum of 8 inches o.c., in at least 1 surface.
 1. Fittings and accessories mate and match with channels and are from the same manufacturer.
- C. Raceway and Cable Supports: Manufactured clevis hangers, riser clamps, straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps or "click"- type hangers.
- D. Sheet-Metal Sleeves: 0.0276-inch or heavier galvanized sheet steel, round tube, closed with welded longitudinal joint.
- E. Pipe Sleeves: ASTM A 53, Type E, Grade A, Schedule 40, galvanized steel, plain ends.
- F. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for nonarmored electrical cables in riser conduits. Plugs have number and size of conductor gripping holes as required to suit individual risers. Body constructed of malleable iron casting with hot-dip galvanized finish.
- G. Expansion Anchors: Stainless steel wedge or sleeve type.
- H. Toggle Bolts: All-steel springhead type.
- I. Powder-Driven Threaded Studs: Heat-treated steel.

2.4 FABRICATED SUPPORTING DEVICES

- A. Pipe Sleeves: Provide pipe sleeves of one of the following:
 1. Sheet Metal: Fabricate from galvanized sheet metal; round tube closed with snap lock joint, welded spiral seams, or welded longitudinal joint. Fabricate sleeves from the following gage metal for sleeve diameter noted:
 - a. 3 inch and smaller: 20 gauge.
 - b. 4-inch to 6-inch: 16 gauge.
 - c. Over 6-inch: 14 gauge.
 2. Steel Pipe: Fabricate from Schedule 40 galvanized steel pipe.
 3. Plastic Pipe: Fabricate from Schedule 80 PVC plastic pipe.

2.5 ELECTRICAL SUPPORTING METHODS

- A. Damp Locations and Outdoors: Stainless Steel materials, U-channel system components.
- B. Dry Locations: Steel materials.
- C. Support Clamps for PVC Raceways: Click-type clamp system.

- D. Conform to manufacturer's recommendations for selecting supports.
- E. Strength of Supports: Adequate to carry all present and future loads, times a safety factor of at least 4; 200 lb minimum design load.

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 installation.
- 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 the load plus a minimum of 200 lbs safety allowance.
 - 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. 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.
 - 5. Space supports for raceways in accordance with with NEC.
 - 6. In vertical 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.
- D. In open overhead spaces, support sheet metal boxes directly from the building structure 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.
- E. Sleeves: Install in concrete slabs and walls and all other fire-rated floors and walls for raceways and cable installations. For sleeves through fire rated-wall or floor construction, apply UL-listed firestopping sealant in gaps between sleeves and enclosed conduits and cables in accordance with "Fire Resistant Joint Sealers" requirement of Contract Documents and applicable code requirements.

- F. 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. 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. All device boxes in sheetrock walls will be tight before, during and after installation of sheetrock.
- G. Cutting and Patching: Obtain Engineer's approval before cutting and patching on structural members of building surfaces.

END OF SECTION 26 05 29

SECTION 26 05 33 – RACEWAY AND BOXES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes raceways for electrical wiring. Types of raceways in this Section include only the following:
1. Metal conduit and tubing.
 2. Nonmetallic conduit and ducts.
 3. Flexible metal, liquid-tight conduit.
 4. Conduit bodies.
 5. Outlet and device boxes.
 6. Junction and pull boxes.
 7. Wireway.

1.2 SUBMITTALS

- A. Furnish submittals in accordance with Contract Documents.
- B. Action Submittals: Manufacturer's Literature:
1. Rigid galvanized steel conduit.
 2. Intermediate metal conduit
 3. PVC Schedule 40 conduit.
 4. PVC-coated rigid galvanized steel conduit, submittal to include copy of manufacturer's warranty.
 5. Flexible metal, liquid-tight conduit.
 6. Conduit fittings.
 7. Wireways.
 8. Device boxes for use in hazardous areas.
 9. Junction and pull boxes used at or below grade.
 10. Large junction and pull boxes.

11. Terminal junction boxes.
 12. Precast Manholes and Handholes:
 - a. Dimensional drawings and descriptive literature.
 - b. Traffic loading calculations.
 - c. Accessory information.
 13. Equipment and machinery proposed for bending metal conduit.
 14. Method for bending PVC conduit less than 30 degrees.
 15. Seismic anchorage and bracing drawings and cut sheets.
 16. Conduit Layout:
 - a. Provide drawings for underground and concealed conduits including, but not limited to ductbanks, under floor slabs, concealed in floor slabs, and concealed in walls.
 - b. Provide plan and section showing arrangement and location of conduit and duct bank required for:
 - 1) Low voltage feeder and branch circuits.
 - 2) Instrumentation and control systems.
 - 3) Communications systems.
 - 4) Empty conduit for future use.
 - 5) Electronic CAD; scale not greater than 1 inch equals 20 feet.
- C. Informational Submittals:
1. Seismic anchorage and bracing calculations as required to meet building code.
 2. Manufacturer's certification of training for PVC-coated rigid galvanized steel conduit installer.

1.3 QUALITY ASSURANCE

- A. Comply with section 26 05 00 – General Requirements for Electrical Work.
- B. PVC-Coated, Rigid Galvanized Steel Conduit Installer: Certified by conduit manufacturer as having received training on installation procedures.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers complying with the Quality Assurance requirements are acceptable.

2.2 METAL CONDUIT AND TUBING

A. Rigid Metal Conduit (RMC):

1. Meet requirements of NEMA -ANSI C80.1 and UL 6.
2. Material: Hot-dip galvanized with chromated protective layer or compatible organic layer.
3. Threads shall be hot galvanized after cutting.

B. PVC-Coated Rigid Galvanized Steel Conduit:

1. Meet requirements of NEMA RN 1 and ETL.
2. Material:
 - a. Meet requirements of NEMA -ANSI C80.1 and UL 6.
 - b. Exterior Finish: PVC coating, 40-mil nominal thickness; bond to metal shall have tensile strength greater than PVC.
 - c. Interior finish: Urethane coating, 2-mil nominal thickness.
3. Threads: Hot-dipped galvanized and factory coated with urethane.
4. Bendable without damage to interior or exterior coating.

C. Intermediate Metal Conduit (IMC):

1. Meet requirements of NEMA – ANSI C80.6 and UL 1242.
2. Material: Hot-dip galvanized with chromated and lacquered protective layer.

D. Electrical Metallic Tubing (EMT) and Fittings: ANSI C80.3.

E. Flexible Metal Conduit: UL 1, zinc-coated steel.

F. Flexible Metal, Liquid-Tight Conduit:

1. UL 360 listed for 105 degrees C insulated conductors.
2. Material: Galvanized steel with extruded PVC jacket.

2.3 NONMETALLIC CONDUIT AND DUCTS

- A. Electrical Nonmetallic Tubing (ENT): Is not allowed.
- B. Rigid Nonmetallic Conduit (RNC): NEMA TC 2 and UL 651, Schedule 80 PVC.
- C. PVC Schedule 40 Conduit:
 - 1. Meet requirements of NEMA TC 2 and UL 651.
 - 2. UL listed for concrete encasement, underground direct burial, concealed or direct sunlight exposure, and 90 degrees C insulated conductors.
- D. PVC Conduit and Tubing Fittings: NEMA TC 3; match to conduit or conduit/tubing type and material.
- E. Flexible, Nonmetallic, Liquid-Tight Conduit: Fittings: UL 1660. Fittings shall be specifically approved for use with this raceway.
 - 1. Material: PVC core with fused flexible PVC jacket.
 - 2. UL 1660 listed for:
 - a. Dry Conditions: 80 degrees C insulated conductors.
 - b. Wet Conditions: 60 degrees C insulated conductors.
 - 3. Manufacturers and Products:
 - a. Carlon; Carflex or X-Flex.
 - b. T & B; Xtraflex LTC or EFC.
 - c. Or approved equal.
- F. Innerduct:
 - 1. Resistant to spread of fire, per requirements of UL 2024.
 - 2. Smooth or corrugated HDPE.
 - 3. Textile Manufacturer: Maxcell or approved equal.
- G. Conduit, Tubing, and Duct Accessories: Types, sizes, and materials complying with manufacturer's published product information. Mate and match accessories with raceway.

2.4 CONDUIT BODIES

- A. General: Form 8 only, shapes, and sizes as required to suit individual applications and NEC requirements. Match conduit type being installed on.

- B. Provide matching gasketed covers secured with corrosion-resistant screws.
- C. Metallic Conduit and Tubing: Use metallic form 8 conduit bodies. Use bodies with threaded hubs for threaded raceways.
- D. Manufacturers and Products (For Normal Conditions):
 - 1. Appleton; Form 8 conduit bodies.
 - 2. Crouse-Hinds; Form 8 threaded condulets.
 - 3. Killark; Series O electrolets.
 - 4. Thomas & Betts; Form 8.
 - 5. Approved equal.
- E. Manufacturers (For Hazardous Locations):
 - 1. Appleton.
 - 2. Crouse-Hinds.
 - 3. Killark.
 - 4. Approved equal.

2.5 FITTINGS

- A. Rigid Galvanized Steel and Intermediate Metal Conduit:
 - 1. General:
 - a. Meet requirements of UL 514B.
 - b. Type: Threaded, galvanized. Set screw and threadless compression fittings not permitted.
 - 2. Bushing:
 - a. Material: Malleable iron with integral insulated throat, rated for 150 degrees C.
 - b. Manufacturers and Products:
 - 1) Appleton; Series BU-I.
 - 2) O-Z/Gedney; Type HB.
 - 3) Approved equal.
 - 3. Grounding Bushing:

- a. Material: Malleable iron with integral insulated throat rated for 150 degrees C, with solderless lugs.
 - b. Manufacturers and Products:
 - 1) Appleton; Series GIB.
 - 2) O-Z/Gedney; Type HBLG.
 - 3) Approved equal.
4. Conduit Hub:
- a. Material: Malleable iron with insulated throat with bonding screw.
 - b. UL listed for use in wet locations.
 - c. Manufacturers and Products:
 - 1) Appleton, Series HUB-B.
 - 2) O-Z/Gedney; Series CH.
 - 3) Meyers; ST Series.
 - 4) Approved equal.
5. Couplings: As supplied by conduit manufacturer.
6. Unions:
- a. Concrete tight, hot-dip galvanized malleable iron.
 - b. Manufacturers and Products:
 - 1) Appleton; Series SCC bolt-on coupling or Series EC three-piece union.
 - 2) O-Z/Gedney; Type SSP split coupling or Type 4 Series, three-piece coupling.
 - 3) Approved equal.
7. Conduit Sealing Fitting:
- a. Manufacturers and Products:
 - 1) Appleton; Type EYF, EYM, or ESU.
 - 2) Crouse-Hinds; Type EYS or EZS.
 - 3) Killark; Type EY or Type EYS.

- 4) Approved equal.
8. Drain Seal:
 - a. Manufacturers and Products:
 - 1) Appleton; Type EYD.
 - 2) Crouse-Hinds; Type EYD or Type EZD.
 - 3) Approved equal.
9. Drain/Breather Fitting:
 - a. Manufacturers and Products:
 - 1) Appleton; Type ECDB.
 - 2) Crouse-Hinds; ECD.
 - 3) Approved equal.
10. Expansion Fitting:
 - a. Manufacturers and Products:
 - 1) Deflection/Expansion Movement:
 - a) Appleton; Type DF.
 - b) Crouse-Hinds; Type XD.
 - c) Approved equal.
 - 2) Expansion Movement Only:
 - a) Appleton; Type XJ.
 - b) Crouse-Hinds; Type XJ.
 - c) Thomas & Betts; XJG-TP.
 - d) Approved equal.
11. Cable Sealing Fitting:
 - a. To form watertight nonslip cord or cable connection to conduit.
 - b. For Conductors with OD of 1/2 inch or Less: Neoprene bushing at connector entry.
 - c. Manufacturers and Products:

- 1) Appleton; CG-S.
- 2) Crouse-Hinds; CGBS.
- 3) Approved equal.

B. PVC Conduit:

1. Meet requirements of NEMA TC 3.
2. Type: PVC, slip-on.

C. PVC-Coated Rigid Galvanized Steel Conduit:

1. Meet requirements of UL 514B.
2. Fittings: Rigid galvanized steel type, PVC coated by conduit manufacturer.
3. Conduit Bodies: Form 8, Cast metal hot-dipped galvanized or urethane finish. Cover shall be screw type only and of same material as conduit body. PVC coated by conduit manufacturer.
4. Finish: 40-mil PVC exterior, 2-mil urethane interior.
5. Overlapping pressure-sealing sleeves.
6. Conduit Hangers, Attachments, and Accessories: PVC-coated.
7. Manufacturers:
 - a. Robroy Industries
 - b. Ocal
 - c. Plasti-Bond
 - d. Approved equal.
8. Expansion Fitting:
 - a. Manufacturer and Product: Ocal; OCAL-BLUE XJG.
 - b. Approved equal.

D. Flexible Metal, Liquid-Tight Conduit:

1. Metal insulated throat connectors with integral nylon or plastic seal rings rated for 105 degrees C.
2. Manufacturers and Products:
 - a. Thomas & Betts; Series 5333.

- b. O-Z/Gedney; Series 4Q.
 - c. Approved equal.
- E. Flexible, Nonmetallic, Liquid-Tight Conduit:
 - 1. Meet requirements of UL 514B.
 - 2. Type: High strength plastic body, complete with lock nut, O-ring, threaded ferrule, sealing ring, and compression nut.
 - 3. Body/compression nut (gland) design to ensure high mechanical pullout strength and watertight seal.
 - 4. Manufacturers and Products:
 - a. Carlon; Type LT.
 - b. O-Z/Gedney; Type 4Q-P.
 - c. Thomas & Betts; Series 6300.
 - d. Approved equal.
- F. Flexible Coupling, Hazardous Locations:
 - 1. Approved for use in atmosphere involved.
 - 2. Rating: Watertight and UL listed for use in Class I, Division 1 and 2 areas.
 - 3. Outer bronze braid and an insulating liner.
 - 4. Conductivity equal to a similar length of rigid metal conduit.
 - 5. Manufacturers and Products:
 - a. Crouse-Hinds; Type ECGJH or Type ECLK.
 - b. Appleton; EXGJH or EXLK.
 - c. Approved equal.
- G. Watertight Entrance Seal Device:
 - 1. New Construction:
 - a. Material: Oversized sleeve, malleable iron body with sealing ring, pressure ring, grommet seal, and pressure clamp.
 - b. Manufacturer and Product: O-Z/Gedney; Type FSK or Type WSK or approved equal, as required.

2. Cored-Hole Application:
 - a. Material: Assembled dual pressure disks, neoprene sealing ring, and membrane clamp.
 - b. Manufacturer and Product: O-Z/Gedney; Series CSM or approved equal.

2.6 OUTLET AND DEVICE BOXES

- A. Sheet Steel: One-piece drawn type, zinc-plated or cadmium-plated.
- B. Cast Metal:
 1. Box: Malleable iron.
 2. Cover: Gasketed, weatherproof, malleable iron, or cast ferrous metal, with stainless steel screws.
 3. Hubs: Threaded.
 4. Lugs: Cast Mounting.
 5. Manufacturers and Products, Nonhazardous Locations:
 - a. Crouse-Hinds; Type FS or Type FD.
 - b. Appleton; Type FS or Type FD.
 - c. Killark.
 - d. Approved equal.
 6. Manufacturers and Products, Hazardous Locations:
 - a. Crouse-Hinds; Type GUA or Type EAJ.
 - b. Appleton; Type GR.
 - c. Approved equal.
- C. PVC-Coated Cast Metal:
 1. Type: One-piece.
 2. Material: Malleable iron, cast ferrous metal, or cast aluminum.
 3. Coating:
 - a. Exterior Surfaces: 40-mil PVC.
 - b. Interior Surfaces: 2-mil urethane.

4. Manufacturers:
 - a. Robroy Industries.
 - b. Ocal.
 - c. Approved equal.
- D. Nonmetallic:
 1. Box: PVC.
 2. Cover: PVC, weatherproof, with stainless steel screws.
 3. Manufacturer and Product: Carlon; Type FS or Type FD, with Type E98 or Type E96 covers, or approved equal.

2.7 JUNCTION AND PULL BOXES

- A. Outlet Box Used as Junction or Pull Box: As specified under Article Outlet and Device Boxes.
- B. Conduit Bodies Used as Junction Boxes: As specified under Article Fittings.
- C. Large Sheet Steel Box:
 1. NEMA 250, Type 1.
 2. Box: Code-gauge, galvanized steel.
 3. Cover: Hinged with ¼ turn fasteners.
- D. Large Cast Metal Box:
 1. NEMA 250, Type 4.
 2. Box: Cast malleable iron or electrogalvanized finished, with drilled and tapped conduit entrances and exterior mounting lugs.
 3. Gasket: Neoprene.
 4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
 5. Manufacturer and Product, Surface Mounted, Hinged Type:
 - a. Cover: Hinged with bolt/wing nut fasteners.
 - b. O-Z/Gedney; Series YW
 - c. Approved equal.
 6. Manufacturers and Products, Recessed Type:

- a. Crouse-Hinds; Type WJBF.
 - b. O-Z/Gedney; Series YR.
 - c. Approved equal.
- E. Large Cast Metal Box, Hazardous Locations:
1. NEMA 250 Type 7 or Type 9 as required for Class, Division, and Group involved.
 2. Box: Cast ferrous metal, electro-galvanize finished or copper-free aluminum with drilled and tapped conduit entrances.
 3. Cover: As required by space classification.
 4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
 5. Manufacturers and Products:
 - a. Crouse-Hinds; Type EJB.
 - b. O-Z/Gedney; Series AJBEW.
 - c. Approved equal.
- F. Large Stainless Steel Box:
1. NEMA 250 Type: 4X
 2. Box: 14-gauge, ASTM A240/A240M, Type: 316 stainless steel, with white enamel painted interior mounting panel.
 3. Cover: Hinged with ¼ turn fasteners.
 4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
 5. Manufacturers:
 - a. Hoffman Engineering Co.
 - b. Robroy Industries.
 - c. Wiegman.
 - d. Approved equal.
- G. Large Steel Box:
1. NEMA 250 Type 3R
 2. Box: 14 gauge steel, with white enamel painted interior and gray primed exterior, over phosphated surfaces. Provide gray finish as approved by Engineer.

3. Cover: Hinged with ¼ turn fasteners.
 4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
 5. Manufacturers:
 - a. Hoffman Engineering Co.
 - b. Robroy Industries.
 - c. Wiegman.
 - d. Approved equal.
- H. Large Nonmetallic Box:
1. NEMA 250 Type A: 4X.
 2. Box: High-impact, fiberglass-reinforced polyester or engineered thermoplastic, with stability to high heat.
 3. Cover: Hinged with ¼ turn fasteners.
 4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
 5. Conduit hubs and mounting lugs.
 6. Manufacturers and Products:
 - a. Crouse-Hinds; Type NJB.
 - b. Carlon; Series N, C, or H.
 - c. Robroy Industries.
 - d. Approved equal.
- I. Underground Pull Box, Nontraffic Areas:
1. Box: Material type HDPE, with extension.
 2. Cover: HDPE with locking bolts.
 3. Cover Marking: ELECTRICAL, CONTROL, SIGNAL, TELEPHONE, or as shown.
 4. Size: 10 inches by 17 inches, minimum.
 5. Manufacturers and Products:
 - a. Oldcastle/Carson Industries; L Series 1220-12

- b. Hubble-Quarzite; 1220-12
 - c. Approved equal.
- J. Concrete Box, Traffic Areas:
- 1. Box: Reinforced, cast concrete with extension and bottom slab.
 - 2. Cover: Steel checked plate; H/20 loading. Traffic-rated boxes to have hinged lid to allow access.
 - 3. Cover Marking: ELECTRICAL, CONTROL, SIGNAL, TELEPHONE, or as shown.
 - 4. Manufacturers and Products:
 - a. Oldcastle Precast; Model 3030-LA (3030-SB with No. 3030-P Cover).
 - b. Christy, Concrete Products, Inc.; B1017.
 - c. Approved equal.

2.8 TERMINAL JUNCTION BOX

- A. Cover: Hinged with ¼ turn fasteners, unless otherwise shown.
- B. Interior Finish: Paint with white enamel or lacquer.
- C. Terminal Blocks:
 - 1. Separate connection point for each conductor entering or leaving box.
 - 2. Spare Terminal Points: 25 percent, minimum.

2.9 WIREWAYS

- A. General: Electrical wireways shall be of types, sizes, and number of channels as indicated. Fittings and accessories including but not limited to couplings, offsets, elbows, expansion joints, adapters, hold-down straps, and end caps shall match and mate with wireway as required for complete system.
- B. Where features are not indicated, select to fulfill wiring requirements and comply with applicable provisions of NEC.
- C. METAL WIREWAYS
 - 1. Meet requirements of UL 870.
 - 2. Type: Steel-enclosed, lay-in type.
 - 3. Cover: Removable, screw type.

4. Rating: Outdoor raintight.
5. Finish: Rust inhibiting phosphatizing primer and gray baked enamel.
6. Hardware: Plated to prevent corrosion; screws installed toward the inside protected by spring nuts or otherwise guarded to prevent wire insulation damage.
7. Knockouts: Without knockouts, unless otherwise indicated.
8. Manufacturers:
 - a. Circle AW.
 - b. Hoffman.
 - c. Square D.
 - d. Approved equal.

D. NONMETALLIC WIREWAY

1. Rating: Outdoor, corrosion resistant, raintight, NEMA Type 12 and Type 3R.
2. Type: Fiberglass-enclosed, with removable cover.
3. Captivated, corrosion-resistant cover screws.
4. Oil-resistant gaskets.
5. Meet UL cold impact test to minus 35 degrees C.
6. Manufacturer: Hoffman or approved equal.

2.10 PRECAST HANDHOLES

- A. Concrete Strength: Minimum, 3,000 psi compressive, in 28 days.
- B. Loading: AASHTO, H-20 in accordance with ASTM C857.
- C. Drainage:
 1. Slope floors toward drain points, leaving no pockets or other nondraining areas.
 2. Provide drainage outlet or sump at low point of floor constructed with a heavy, cast iron, slotted or perforated hinged cover, and a minimum 4-inch outlet and outlet pipe.
- D. Raceway Entrances:
 1. Provide on all four sides.
 2. Provide knockout panels or precast individual raceway openings.

3. At entrances where raceways are to be installed by others, provide minimum 12-inch-high by 24-inch-wide knockout panels for future raceway installation.
- E. Embedded Pulling Iron:
1. Material: 3/4-inch-diameter stock, fastened to overall steel reinforcement before concrete is placed.
 2. Location:
 - a. Wall: Opposite each raceway entrance and knockout panel for future raceway entrance.
 - b. Floor: Centered below manhole or handhole cover.
- F. Cable Racks:
1. Arms and Insulators: Adjustable, of sufficient number to accommodate cables for each raceway entering or leaving manhole, including spares.
 2. Wall Attachment:
 - a. Adjustable inserts in concrete walls. Bolts or embedded studs not permitted.
 - b. Insert Spacing: Maximum 3 feet on center for inside perimeter of manhole.
 - c. Arrange in order that spare raceway ends are clear for future cable installation.
- G. Handhole Frames and Covers:
1. Material: Steel, hot-dipped galvanized.
 2. Cover Type: Solid, bolt-on, torsion spring, of diamond design. Large vaults to have hinged lids.
 3. Cover Loading: AASHTO H-20.
 4. Cover Designation: Burn by welder, on upper side in integral letters, minimum 2 inches in height, appropriate titles:
 - a. 600 Volts and Below: ELECTRIC LV, CONTROL, SIGNAL, TELEPHONE.
- H. Hardware: Steel, hot-dip galvanized.
- I. Furnish knockout for ground rod in each handhole.
- J. Manufacturers:
1. Utility Vault Co.

2. Penn-Cast Products, Inc.
3. Concrete Conduit Co.
4. Associated Concrete Products, Inc.
5. Pipe, Inc.
6. Approved equal.

2.11 ACCESSORIES

A. Duct Bank Spacers:

1. Modular Type:

- a. Nonmetallic, interlocking, for multiple conduit sizes.
- b. Suitable for all types of conduit.
- c. Manufacturers:
 - 1) Underground Device, Inc.
 - 2) Carlon
 - 3) Approved equal

2. Template Type:

- a. Nonmetallic, custom made one-piece spacers.
- b. Suitable for all types of conduit.
- c. Material: HDPE or polypropylene, 1/2-inch minimum thickness.
- d. Conduit openings cut 1 inch larger than conduit outside diameter.
- e. Additional openings for stake-down, rebar, and concrete flow through as required.
- f. Manufacturer and Product: SP Products; Quik Duct or approved equal.

B. Identification Devices:

1. Raceway Tags:

- a. Material: Phenolic.
- b. Shape: Rectangular.
- c. Raceway Designation: Tag name engraved.

- d. Tags relying on adhesives or taped-on markers not permitted.
- 2. Warning Tape:
 - a. Material: Polyethylene, 4-mil gauge with detectable strip.
 - b. Color: Red.
 - c. Width: Minimum 3 inches.
 - d. Designation: Warning on tape that electric circuit is located below tape.
 - e. Identifying Letters: Minimum 1-inch-high permanent black lettering imprinted continuously over entire length.
 - f. Manufacturers and Products:
 - 1) Panduit; Type HTDU.
 - 2) Reef Industries; Terra Tape.
 - 3) Approved equal.
- 3. Buried Raceway Marker:
 - a. Material: Sheet bronze, consisting of double-ended arrows, straight for straight runs and bent at locations where runs change direction.
 - b. Designation: Engrave to depth of 3/32 inch; ELECTRIC CABLES, in letters 1/4-inch high.
 - c. Minimum Dimension: 1/4 inch thick, 10 inches long, and 3/4 inch wide.
- C. Raceway Coating: Clean and paint.
- D. Heat Shrinkable Tubing:
 - 1. Material: Heat-shrinkable, cross-linked polyolefin.
 - 2. Semi-flexible with meltable adhesive inner liner.
 - 3. Color: Black.
 - 4. Manufacturers:
 - a. Raychem.
 - b. 3M.
 - c. Approved equal.
- E. Wraparound Duct Band:

1. Material: Heat-shrinkable, cross-linked polyolefin, precoated with hot-melt adhesive.
2. Width: 50 mm minimum.
3. Manufacturer and Product: Raychem; Type TWDB or approved equal.

PART 3 - EXECUTION

3.1 GENERAL

- A. Conduit and tubing sizes shown are based on use of copper conductors.
- B. Comply with NECA Installation Standards.
- C. Crushed or deformed raceways not permitted.
- D. Maintain raceway entirely free of obstructions and moisture.
- E. Immediately after installation, plug or cap raceway ends with watertight and dust-tight seals until time for pulling in conductors.
- F. Sealing Fittings: Provide drain seal in vertical raceways where condensate may collect above sealing fitting.
- G. Avoid moisture traps where possible. When unavoidable in exposed conduit runs, provide junction box and drain fitting at conduit low point.
- H. Group raceways installed in same area.
- I. Proximity to Heated Piping: Install raceways minimum 12 inches from parallel runs.
- J. Follow structural surface contours when installing exposed raceways. Avoid obstruction of passageways.
- K. Run exposed raceways parallel or perpendicular to walls, structural members, or intersections of vertical planes.
- L. Block Walls: Do not install raceways in same horizontal course or vertical cell with reinforcing steel.
- M. Install watertight fittings in outdoor, underground, or wet locations.
- N. Paint threads and cut ends, before assembly of fittings, galvanized conduit, PVC-coated galvanized conduit, or IMC installed in exposed or damp locations with zinc-rich paint or liquid galvanizing compound.
- O. Metal conduit shall be reamed, burrs removed, and cleaned before installation of conductors, wires, or cables.
- P. Do not install raceways in concrete equipment pads, foundations, or beams without Engineer approval.

- Q. Horizontal raceways installed under floor slabs shall lie completely under slab, with no part embedded within slab.
- R. Install concealed, embedded, and buried raceways so that they emerge at right angles to surface and have no curved portion exposed.
- S. Install conduits for fiber optic cables, telephone cables, and Category 6 data cables in strict conformance with the requirements of TIA 569B.
- T. Conceal conduit (in walls, under slabs, etc.), unless noted otherwise.

3.2 REUSE OF EXISTING CONDUITS

- A. Where Drawings indicate existing conduits may be reused, they may be reused only where they meet the following criteria.
 - 1. Conduit is in useable condition with no deformation, corrosion, or damage to exterior surface.
 - 2. Conduit is sized per the NEC.
 - 3. Conduit is of the type specified in Contract Documents.
 - 4. Conduit is supported as specified in Contract Documents.
- B. Conduit shall be reamed with wire brush, then with a mandrel approximately 1/4 inch smaller than raceway inside diameter then cleaned prior to pulling new conductors.

3.3 CONDUIT APPLICATION

- A. Diameter: Minimum $\frac{3}{4}$ inch.
- B. Exterior, Outdoors: Use the following methods:
 - 1. Exposed: PVC Coated Rigid metal conduit.
 - 2. Concealed: Rigid nonmetallic conduit (sched 40), concealed elbows to be PVC sched 40. Elbows that transition to exposed shall be PVC Coated RMC.
 - 3. Underground: Rigid nonmetallic conduit (sched 40), elbows to be PVC Coated RMC. Reference part 3.3 D for indoor/under slab.
 - 4. Indoors or Outdoors: Connection to vibrating equipment including transformers and hydraulic, pneumatic, or electric solenoid or motor-driven equipment in moist or humid location or corrosive atmosphere, or where subject to water spray or dripping oil, grease, or water: liquid tight flexible metallic conduit.
- C. Indoors: Use the following methods:
 - 1. Connection to Vibrating Equipment: Including transformers and hydraulic, pneumatic, or electric solenoid or motor-operated equipment: liquid tight flexible metallic conduit.

2. Exposed Wet/Corrosive areas: Installation to provide protection from wet area, allow for wash down with additional physical protection below six feet.
 - a. Areas from six feet and below to be PVC Coated RMC.
 - b. Areas above six feet to be a minimum of EMT with raintight fittings.
 3. Exposed Dry Areas: Electrical metallic tubing, rigid metal conduit (Only areas classified as dry and approved by Engineer). Electrical room, fire riser room, generator room, blower room, closet, etc.
 4. Concealed in Ceilings: Electrical metallic tubing. AC/MC cable NOT ALLOWED, unless noted on drawings.
 5. Concealed in Walls: Rigid nonmetallic conduit (sch 40), concealed elbows to be PVC (sch 40), elbows which transition to exposed to be PVC Coated RMC.
- D. Underslab: Sch 40 PVC: Elbows transitional through slab to be PVC coated RMC. Per details E2 and E17. Aboveground, Embedded in Concrete Walls, Ceilings, or Floors: PVC Schedule 40.
- E. Direct Earth Burial: PVC Schedule 40.
- F. Exterior Light Pole Foundations: PVC sched 40.
- G. Concrete-Encased Raceways: PVC Schedule 40, except where rigid galvanized steel is indicated.
- H. Use of PVC coated RMC elbows: All 90 degree bends on conduits located outside and direct buried or embedded in concrete are to be PVC coated RMC. All interior / exterior conduits that transition from embedded/direct buried etc. to exposed shall be PVC coated RMC elbows (90's) as per the details E16 and E17. All other 90 degree bends located within the confines of the building footprint either embedded in walls floors etc. or direct buried may be installed as PVC SCH 40.
- I. Hazardous Locations:
1. PVC coated rigid metal conduit up to six feet. Conduit above six feet, Rigid galvanized steel.

3.4 INSTALLATION

- A. General: Install electrical raceways in accordance with requirements of NEC, and as follows:
 - B. Conceal all 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 and square and at proper elevations.
 - C. Elevation of Raceway: Where possible, install horizontal raceway runs above water and steam piping.

- D. Complete installation of electrical raceways before starting installation of conductors within raceways.
- E. Provide supports for raceways as specified in Specification Section 26 05 00 – General Requirements for Electrical Work.
- F. Prevent foreign matter from entering raceways by using temporary closure protection.
- G. Protect stub-ups from damage where conduits rise from floor slabs. Arrange so curved portion of bends is not visible above the finished slab.

Make bends and offsets so the inside diameter is not effectively reduced. Crushed or deformed raceways not permitted. Unless otherwise indicated, keep the legs of a bend in the same plane and the straight legs of offsets parallel.
- H. Use raceway fittings that are of types compatible with the associated raceway and suitable for the use and location. For rigid metal conduit, use threaded rigid steelconduit fittings except as otherwise indicated. EMT set screw connectors and couplers are to be steel.
- I. Run concealed raceways with a minimum of bends in the shortest practical distance considering the type of building construction and obstructions except as otherwise indicated. This does not apply to conduits in crawl spaces.
- J. Raceways embedded in slabs: Not allowed without engineering approval.
- K. Install exposed raceways parallel and perpendicular to nearby surfaces or structural members and follow the surface contours as much as practical.
- L. Run exposed, parallel, or banked raceways together.
- M. Join raceways with fittings designed and approved for the purpose and make joints tight. Where joints cannot be made tight, use bonding jumpers to provide electrical continuity of the raceway system. Make raceway terminations tight. 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.
- N. Terminations: Where raceways are terminated with locknuts and bushings, align the raceway to enter squarely and install the locknuts with dished part against the box. Where terminations cannot be made secure with one locknut, use two locknuts, one inside and one outside the box.
- O. 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.
- P. Install pull wires in empty raceways. Use monofilament plastic line having not less than 200 lb tensile strength. Leave not less than 12 inches of slack at each end of the pull wire.

- Q. Communication and Signal System Raceways 2 Inch Trade Size and Smaller: In addition to the above requirements, install raceways 2 inch and smaller trade size in maximum lengths at 150 feet and with a maximum of two, 90 deg bends or equivalent. Install pull or junction boxes where necessary to comply with these requirements.
- R. Stub-up Connections: Per detail E2.
- S. Flexible Connections: Use short length (maximum of 3 ft.) of flexible conduit for recessed and semi-recessed lighting fixtures, for equipment subject to vibration, noise transmission, or movement; and for all motors. Use liquid tight flexible metallic conduit in wet locations. Install separate ground conductor across flexible connections. Flexible conduit will not be allowed to route conduits into fixed panelboards, gutter, or other unauthorized locations.
- T. Surface Metal Raceway: Install a separate green ground conductor in raceway from the junction box supplying the raceway to receptacle or fixture ground terminals.
- U. Raceway Installed Above Accessible Ceilings: Raceway located above accessible ceilings shall be a minimum of 24 inches above finished ceiling or mounted direct to structure, whichever is less.

3.5 FLEXIBLE CONNECTIONS

- A. For motors, wall or ceiling mounted fans and unit heaters, dry type transformers, electrically operated valves, instrumentation, and other locations approved by Engineer where flexible connection is required to minimize vibration:
 - 1. Conduit Size 4 Inches or Less: Flexible, liquid-tight conduit.
 - 2. Conduit Size Over 4 Inches: Nonflexible.
 - 3. Wet or Corrosive Areas: Flexible, **metal** liquid-tight.
 - 4. Dry Areas: Nonmetallic, if installed on conduits not derived from under slabs; otherwise, flexible, metallic liquid-tight to allow bonding of raceway extending through concrete.
 - 5. Hazardous Areas:
 - a. Flexible coupling suitable for Class I, Division 1 areas
 - b. Liquidtight Flexible Metal Conduit suitable for Class 1, Division 2 areas.
- B. Suspended Lighting Fixtures in Dry Areas: Non-metallic, liquid-tight conduit.
- C. Outdoor Areas, Process Areas Exposed to Moisture, and Areas Required to be Oiltight and Dust-Tight: Flexible metal, liquid-tight conduit.
- D. Flexible Conduit Length: 18 inches minimum, 36 inches maximum; sufficient to allow movement or adjustment of equipment.

3.6 PENETRATIONS

- A. Make at right angles, unless otherwise shown.
- B. Notching or penetration of structural members, including footings and beams, not permitted.
- C. Fire-Rated Walls, Floors, or Ceilings: Firestop openings around penetrations to maintain fire-resistance rating as specified in Section 26 05 04 – Basic Electrical Materials and Methods.
- D. Apply a single layer of wraparound duct band to metallic conduit protruding through concrete floor slabs to a point 2 inches above and 2 inches below concrete surface.
- E. Concrete Walls, Floors, or Ceilings (Aboveground): Provide nonshrink grout dry-pack, or use watertight seal device.
- F. Entering Structures:
 - 1. General: In hazardous locations, seal raceway at first box or outlet with oakum or expandable plastic compound to prevent entrance of gases or liquids from one area to another.
 - 2. Concrete Roof or Membrane Waterproofed Wall or Floor:
 - a. Provide a watertight seal.
 - b. Without Concrete Encasement: Install watertight entrance seal device on each side.
 - c. With Concrete Encasement: Install watertight entrance seal device on accessible side.
 - d. Securely anchor malleable iron body of watertight entrance seal device into construction with one or more integral flanges.
 - e. Secure membrane waterproofing to watertight entrance seal device in a permanent, watertight manner.
 - 3. Heating, Ventilating, and Air Conditioning Equipment:
 - a. Penetrate equipment in area established by manufacturer.
 - b. Terminate conduit with flexible metal conduit at junction box or conduit attached to exterior surface of equipment prior to penetrating equipment.
 - c. Seal penetration with sealant, as specified in Meridian Electrical Details and Contract Documents.
 - 4. Corrosive-Sensitive Areas:
 - a. Seal conduit passing through room walls.

- b. Seal conduit entering equipment panel boards and field panels containing electronic equipment.
 - c. Seal penetration with sealant, as specified in Meridian Electrical Details E14 and Contract Documents.
5. Existing or Precast Wall (Underground): Core drill wall and install watertight entrance seal device.
6. Nonwaterproofed Wall or Floor (Underground, without Concrete Encasement):
- a. Provide Schedule 40 galvanized pipe sleeve, or watertight entrance seal device.
 - b. Fill space between raceway and sleeve with expandable plastic compound or oakum and lead joint, on each side.
7. Handholes:
- a. Metallic Raceways: Provide insulated grounding bushings.
 - b. Nonmetallic Raceways: Provide bell ends flush with wall.
 - c. Install such that raceways enter as near as possible to one end of wall, unless otherwise shown.

3.7 SUPPORT

- A. Support from structural members only, at intervals not exceeding NFPA 70 requirements. Do not exceed 8 feet in any application. Do not support from piping, pipe supports, or other raceways.
- B. Multiple Adjacent Raceways: Provide ceiling trapeze. For trapeze-supported conduit, allow 20 percent extra space for future conduit.
- C. Application/Type of Conduit Strap:
 - 1. Rigid Steel: Zinc coated steel, pregalvanized steel or malleable iron.
 - 2. PVC-Coated Rigid Steel Conduit: Stainless steel straps
 - 3. Nonmetallic Conduit: Galvanized or stainless steel, based on location.
- D. Provide and attach wall brackets, strap hangers, or ceiling trapeze as follows:
 - 1. Wood: Wood screws.
 - 2. Hollow Masonry Units: Toggle bolts.
 - 3. Concrete or Brick: Expansion shields, or threaded studs driven in by powder charge, with lock washers and nuts.

4. Steelwork: Machine screws.
5. Location/Type of Hardware:
 - a. Dry, Noncorrosive Areas: Galvanized.
 - b. Wet, Noncorrosive Areas: Stainless steel.
 - c. Corrosive Areas: Stainless steel.
- E. Nails or wooden plugs inserted in concrete or masonry for attaching raceway not permitted. Do not weld raceways or pipe straps to steel structures. Do not use wire in lieu of straps or hangers.

3.8 BENDS

- A. Install concealed raceways with a minimum of bends in the shortest practical distance.
- B. Make bends and offsets of longest practical radius. Bends in conduits and ducts being installed for fiber optic cables shall be not less than 20 times cable diameter, 15 inches minimum.
- C. Install with symmetrical bends or cast metal fittings.
- D. Avoid field-made bends and offsets, but where necessary, make with acceptable hickey or bending machine. Do not heat metal raceways to facilitate bending.
- E. Make bends in parallel or banked runs from same center or centerline with same radius so that bends are parallel.
- F. Factory elbows may be installed in parallel or banked raceways if there is change in plane of run, and raceways are same size.
- G. PVC Conduit:
 1. Bends 30 Degrees and Larger: Provide factory-made elbows.
 2. 90 Degree Bends: Provide rigid steel elbows, PVC-coated where direct buried, or as required in details E2 and E17.
 3. Use manufacturer's recommended method for forming smaller bends.
- H. Flexible Conduit: Do not make bends that exceed allowable conductor bending radius of cable to be installed or that significantly restricts conduit flexibility.

3.9 EXPANSION/DEFLECTION FITTINGS

- A. Provide on raceways at structural expansion joints and in long tangential runs.
- B. Provide expansion/deflection joints for 25 degrees F maximum temperature variation.
- C. Install in accordance with manufacturer's instructions.

- D. Reference details E15 through E18.

3.10 PVC CONDUIT

- A. Solvent Welding:
 - 1. Apply manufacturer recommended solvent to joints.
 - 2. Install in order that joint is watertight.
- B. Adapters:
 - 1. PVC to Metallic Fittings: PVC female adapter.
 - 2. PVC to Rigid Metal Conduit or IMC: PVC female adapter.
- C. Belled-End Conduit: Bevel unbelled end of joint prior to joining.

3.11 PVC-COATED RIGID STEEL CONDUIT

- A. Install in accordance with manufacturer's instructions.
- B. Tools and equipment used in cutting, bending, threading and installation of PVC-coated rigid conduit shall be designed to limit damage to PVC coating.
- C. Provide PVC boot to cover exposed threading.

3.12 WIREWAYS

- A. Install in accordance with manufacturer's instructions.
- B. Locate with cover on accessible vertical face of wireway, unless otherwise shown.
- C. Applications:
 - 1. Metal wireway in indoor dry locations.
 - 2. Nonmetallic wireway in indoor process/wet, outdoor, and corrosive locations.

3.13 TERMINATION AT ENCLOSURES

- A. Cast Metal Enclosure: Install manufacturer's premolded insulating sleeve inside metallic conduit terminating in threaded hubs.
- B. Nonmetallic, Cabinets, and Enclosures:
 - 1. Terminate conduit in threaded conduit hubs, maintaining enclosure integrity.
 - 2. Metallic Conduit: Provide ground terminal for connection to maintain continuity of ground system.
- C. Sheet Metal Boxes, Cabinets, and Enclosures:

1. General:
 - a. Install insulated bushing on ends of conduit where grounding is not required.
 - b. Provide insulated throat when conduit terminates in sheet metal boxes having threaded hubs.
 - c. Utilize threaded hubs on sides and bottom of NEMA 3R and NEMA 12 enclosures.
 - d. Terminate conduits at threaded hubs at the tops of NEMA 3R and NEMA 12 boxes and enclosures.
 - e. Terminate conduits at threaded conduit hubs at NEMA 4 and NEMA 4X boxes and enclosures.
 2. Rigid Galvanized Steel and Intermediate Metal Conduit:
 - a. Provide threaded hubs for each enclosure.
 - b. Install grounding bushing at source enclosure.
 - c. Provide bonding jumper from grounding bushing to equipment ground bus or ground pad.
 3. Flexible Metal Conduit: Provide liquid tight metallic fittings with insulated throats and rain tight bushings.
 4. Flexible, Nonmetallic Conduit: Provide nonmetallic, liquid-tight strain relief connectors.
 5. PVC-Coated Rigid Galvanized Steel Conduit: Provide PVC-coated, liquid-tight, metallic connector.
 6. PVC Schedule 40 Conduit: Provide PVC terminal adapter with lock nut, except where threaded hubs required above.
- D. Motor Control Center, Switchgear, and Free-Standing Enclosures:
1. Terminate metal conduit entering bottom with grounding bushing; provide grounding jumper extending to equipment ground bus or grounding pad.
 2. Terminate PVC conduit entering bottom with bell end fittings.
- 3.14 UNDERGROUND RACEWAYS
- A. Grade: Maintain minimum grade of 4 inches in 100 feet, either from one manhole, handhole, or pull box to the next, or from a high point between them, depending on surface contour.

- B. Cover: Maintain minimum **2-foot** cover above **conduit and concrete encasement**, unless otherwise shown.
- C. Make routing changes as necessary to avoid obstructions or conflicts.
- D. Couplings: In multiple conduit runs, stagger so couplings in adjacent runs are not in same transverse line.
- E. Union type fittings not permitted.
- F. Spacers:
 - 1. Provide preformed, nonmetallic spacers designed for such purpose, to secure and separate parallel conduit runs in a trench or concrete encasement.
 - 2. Install at intervals not greater than that specified in NFPA 70 for support of the type conduit used, but in no case greater than 10 feet.
- G. Support conduit so as to prevent bending or displacement during backfilling or concrete placement.
- H. Transition from Underground to Exposed: PVC-coated rigid steel conduit as per the detail E2 or E17.
- I. Installation with Other Piping Systems:
 - 1. Crossings: Maintain minimum 12-inch vertical separation.
 - 2. Parallel Runs: Maintain minimum 12-inch separation.
 - 3. Installation over valves or couplings not permitted.
- J. Provide expansion fittings that allow minimum of 4 inches of movement in vertical conduit runs from underground where exposed conduit will be fastened to or will enter building or structure. Reference detail E16.
- K. Provide expansion/deflection fittings in conduit runs that exit building or structure below grade. Conduit from building wall to fitting shall be PVC-coated rigid steel. Reference detail E18.
- L. Concrete Encasement:
 - 1. Service entrance raceways shall be concrete encased, if noted on drawings.
 - 2. High voltage raceway containing wire or cable with an operating voltage of over 600V shall be concrete encased.
 - 3. Concrete Color: Red.
- M. Backfill:

1. As specified in ISPWC specifications. Controlled low strength fill is an acceptable bedding and pipe zone material. Backfill material to within 12 inches of surface.
2. Do not backfill until inspected by Engineer.

3.15 UNDER SLAB RACEWAYS

- A. Make routing changes as necessary to avoid obstructions or conflicts.
- B. Support raceways so as to prevent bending or displacement during backfilling or concrete placement.
- C. Install raceways with no part embedded within slab and with no interference with slab on grade construction.
- D. Raceway spacing, in a single layer or multiple layers:
 1. 3 inches clear between adjacent 2-inch or larger raceway.
 2. 2 inches clear between adjacent 1-1/2-inch or smaller raceway.
- E. Multiple Layers of Raceways: Install under slab on grade in trench below backfill zone, as specified in ISPWC specifications.
- F. Individual Raceways and Single Layer Multiple Raceways: Install at lowest elevation of backfill zone with spacing as specified herein. Where conduits cross at perpendicular orientation, installation of conduits shall not interfere with placement of under slab fill that meets compaction and void limitations of earthwork specifications.
- G. Under slab raceways that emerge from below slab to top of slab as exposed, shall be located to avoid conflicts with structural slab rebar. Coordinate raceway stub ups with location of structural rebar.
- H. Fittings:
 1. Union type fittings are not permitted.
 2. Provide expansion/deflection fittings in raceway runs that exit building or structure below slab. Locate fittings 18 inches, maximum, beyond exterior wall. Raceway type between building exterior wall to fitting shall be PVC-coated rigid steel. All expansion/deflection fittings shall be inspected and approved by Engineer prior to backfill. Reference detail E17 and E18.
 3. Couplings: In multiple raceway runs, stagger so couplings in adjacent runs are not in same traverse line.

3.16 OUTLET AND DEVICE BOXES

- A. General:
 1. Install plumb and level.

2. Install suitable for conditions encountered at each outlet or device in wiring or raceway system, sized to meet NFPA 70 requirements.
 3. Open no more knockouts in sheet steel device boxes than are required; seal unused openings.
 4. Install galvanized mounting hardware in industrial areas.
- B. Size:
1. Depth: Minimum 2 inches, unless otherwise required by structural conditions. Box extensions not permitted.
 2. Hollow Masonry Construction: Install with sufficient depth such that conduit knockouts or hubs are in masonry void space.
 3. Ceiling Outlet: Minimum 4inch device box, unless otherwise required for installed fixture.
 4. Switch and Receptacle: Minimum 2-inch by 4-inch device box.
- C. Locations:
1. Drawing locations are approximate.
 2. To avoid interference with mechanical equipment or structural features, relocate outlets as directed by Engineer.
 3. Light Fixture: Install in symmetrical pattern according to room layout, unless otherwise shown.
- D. Mounting Height:
1. General:
 - a. Dimensions given to centerline of box.
 - b. Where specified heights do not suit building construction or finish, adjust up or down to avoid interference.
 - c. Do not straddle CMU block or other construction joints.
 2. Light Switch:
 - a. 48 inches above floor.
 - b. When located next to door, install on lock side of door.
 3. Thermostat: 54 inches above floor.
 4. Telephone Outlet:

- a. 15 inches above floor.
 - b. 6 inches above counter tops.
 - c. Wall Mounted: 52 inches above floor.
5. Convenience Receptacle:
- a. General Interior Areas: 18 inches above floor.
 - b. General Interior Areas (Counter Tops): Install device plate bottom or side 2" above backsplash, or 6 inches above counter tops without backsplash.
 - c. Industrial Areas, Workshops: 48 inches above floor.
 - d. Outdoor Areas: 24 inches above finished grade.
6. Special-Purpose Receptacle: 48 inches above floor or as shown.
7. Switch, Motor Starting: 48 inches above floor, unless otherwise indicated on Drawings.
- E. Flush Mounted:
1. Install with concealed conduit.
 2. Install proper type extension rings or plaster covers to make edges of boxes flush with finished surface.
 3. Holes in surrounding surface shall be no larger than required to receive box.
- F. Supports:
1. Support boxes independently of conduit by attachment to building structure or structural member.
 2. Install bar hangers in frame construction or fasten boxes directly as follows:
 - a. Wood: Wood screws.
 - b. Concrete or Brick: Bolts and expansion shields.
 - c. Hollow Masonry Units: Toggle bolts.
 - d. Steelwork: Machine screws.
 3. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.
 4. Provide plaster rings where necessary.
 5. Boxes embedded in concrete or masonry need not be additionally supported.

- G. Install separate junction boxes for flush or recessed lighting fixtures where required by fixture terminal temperature.
- H. Boxes Supporting Fixtures: Provide means of attachment with adequate strength to support fixture.

3.17 JUNCTION AND PULL BOXES

- A. General:
 - 1. Install plumb and level.
 - 2. Installed boxes shall be accessible.
 - 3. Use outlet boxes as junction and pull boxes wherever possible and allowed by applicable codes.
 - 4. Use form 8 conduit bodies as junction and pull boxes where no splices are required and allowed by applicable codes.
 - 5. Install pull boxes where necessary in raceway system to facilitate conductor installation.
 - 6. Install where shown and where necessary to terminate, tap-off, or redirect multiple conduit runs.
 - 7. Install in conduit runs at least every 150 feet or after the equivalent of three right-angle bends.
- B. Flush Mounted:
 - 1. Install with concealed conduit.
 - 2. Holes in surrounding surface shall be no larger than required to receive box.
 - 3. Make edges of boxes flush with final surface.
- C. Mounting Hardware:
 - 1. Noncorrosive Dry Areas: Galvanized.
 - 2. Noncorrosive Wet Areas: Stainless steel.
 - 3. Corrosive Areas: Stainless steel.
- D. Supports:
 - 1. Support boxes independently of conduit by attachment to building structure or structural member.
 - 2. Install bar hangers in frame construction or fasten boxes directly as follows:

- a. Wood: Wood screws.
 - b. Concrete or Brick: Bolts and expansion shields.
 - c. Hollow Masonry Units: Toggle bolts.
 - d. Steelwork: Machine screws.
3. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.
 4. Boxes embedded in concrete or masonry need not be additionally supported.
- E. At or Below Grade:
1. Install boxes for below grade conduit 2" above finished grade in locations outside of paved areas, roadways, or walkways.
 2. If adjacent structure is available, box may be mounted on structure surface just above finished grade in accessible but unobtrusive location.
 3. Obtain **Engineer's** written acceptance prior to installation in paved areas, roadways, or walkways.
 4. Use boxes and covers suitable to support anticipated weights.
- F. Install Drain/breather fittings in NEMA 250 Type 4 and Type 4X enclosures.

3.18 MANHOLES AND HANDHOLES

- A. Excavate, shore, brace, backfill, and final grade in accordance with ISPWC specifications.
- B. Do not install until final raceway grading has been determined. Final grade shall slope away from electrical boxes.
- C. Provide concrete curb around in road boxes. Roadway asphalt, surface treatment etc. to be graded away from box to prevent excess water intrusion.
- D. Install such that raceway enters at nearly right angle and as near as possible to end of wall, unless otherwise shown.
- E. Grounding: As specified in Section 26 05 26 – Grounding and Bonding for Electrical Systems.
- F. Identification: Field stamp covers with handhole number as shown. Stamped numbers to be 1-inch minimum height.

3.19 EMPTY RACEWAYS

- A. Provide permanent, removable cap over each end.
- B. Provide PVC plug with pull tab for underground raceways with end bells.

- C. Provide nylon pull cord.
- D. Identify, as specified in Article Identification Devices, with waterproof tags attached to pull cord at each end, and at intermediate pull point.

3.20 IDENTIFICATION DEVICES

- A. Raceway Tags:
 - 1. Identify per Raceway Schedule designation.
 - 2. For exposed raceways, install tags at each terminus, near midpoint, and at minimum intervals of every 50 feet, whether in ceiling space or surface mounted.
 - 3. Install tags at each terminus for concealed raceways.
 - 4. Provide noncorrosive wire for attachment.
- B. Warning Tape: Install approximately 12 inches above underground or concrete-encased raceways. Align parallel to, and within 12 inches of, centerline of run.
- C. Buried Raceway Marker:
 - 1. Install at grade to indicate direction of underground raceway.
 - 2. Install at bends and at intervals not exceeding 100 feet in straight runs.
 - 3. Embed and secure to top of concrete base, sized 14 inches long, 6 inches wide, and 8 inches deep; top set flush with finished grade.

3.21 PROTECTION OF INSTALLED WORK

- A. Protect products from effects of moisture, corrosion, and physical damage during construction.
- B. Provide and maintain manufactured watertight and dust-tight seals over conduit openings during construction.
- C. Touch up painted conduit threads after assembly to cover nicks or scars.
- D. Touch up coating damage to PVC-coated conduit with patching compound approved by manufacturer. Compound shall be kept refrigerated according to manufacturers' instructions until time of use.

3.22 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

SECTION 26 05 73 – ELECTRICAL SYSTEMS ANALYSIS

PART 1 - GENERAL

1.1 SCOPE

- A. Section includes:
 - 1. Short circuit fault analysis study.
 - 2. Protective device coordination study.
 - 3. Arc-flash hazard study.
- B. The Contractor shall furnish short-circuit and protective device coordination studies for applicable new power system elements, which shall be prepared by a Registered Professional Engineer. The analysis shall be performed and submitted in two phases for initial and final studies.
- C. The Contractor shall furnish an Arc Flash Hazard Analysis Study per NFPA 70E - Standard for Electrical Safety in the Workplace, reference Article 130.5 and Informative Annex D.
- D. It is the Contractor's responsibility for scheduling and coordinating the work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of the Contractor's Work.
- E. The Contractor shall coordinate with the Owner to schedule and attend Electrical System Study meetings as defined in Part 3.
- F. The Contractor shall perform the following:
 - 1. Data collection required for Engineer to complete the Power System Study requirements specified herein for arc flash, short circuit, and coordination studies.
 - 2. Provide information on data collection forms included herein, and additional information as required for Engineer to complete the Power System Study. Data collection form information includes, but is not limited to, equipment types and nameplate data; all services and feeders including size and type of conductors, conduit types, and lengths; overcurrent protection device information including actual catalog numbers, ratings, and available trip settings; transformer information including type, connections, power ratings, and impedance; load nameplate data.
 - 3. Deliver completed data collection forms as specified herein to the City 120 days prior to Project Substantial Completion to be utilized by the City to develop a Power System Study Report.
 - 4. Initially set protective devices to maximum settings during equipment installation, or as recommended by manufacturer.

5. Adjust protective device settings based on Engineer-furnished Power System Study Report results prior to Project Substantial Completion.
 6. Install Engineer-furnished arc flash warning labels on switchboards, motor control centers, panel boards, VFD's, disconnect switches, and other applicable new power system elements prior to Project Substantial Completion.
- G. The Engineer shall perform the following:
1. Prepare a Power System Study Report that includes arc flash, short circuit, and coordination studies for switchboards, motor control centers, panel boards, and other applicable new power system elements. The studies and report will be based on as-installed equipment, circuit, and raceway data collection form information provided by the Contractor to the Engineer.
 2. Deliver final protective device settings and arc flash labels to the Contractor 14 days prior to Project Substantial Completion.

1.2 REFERENCES

- A. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
1. IEEE 141 – Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems (Red Book).
 2. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (Buff Book).
 3. IEEE 399 – Recommended Practice for Industrial and Commercial Power System Analysis (Brown Book).
 4. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings (Gray Book).
 5. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems (Blue Book).
 6. IEEE 1584 – Guide for Performing Arc-Flash Hazard Calculations
- B. American National Standards Institute (ANSI):
1. ANSI C57.12.00 – Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
 2. ANSI C37.13 – Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures
 3. ANSI C37.010 – Standard Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis

4. ANSI C 37.41 – Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories
 5. ANSI C37.5 – Methods for Determining the RMS Value of a Sinusoidal Current Wave and Normal-Frequency Recovery Voltage, and for Simplified Calculation of Fault Currents
- C. The National Fire Protection Association (NFPA)
1. NFPA 70 - National Electrical Code, latest edition
 2. NFPA 70E – Standard for Electrical Safety in the Workplace
- D. National Electrical Manufacturers Association (NEMA):
1. Z535.4 - Product Safety Signs and Labels.
- E. Occupational Safety and Health Standards (OSHA):
1. 29 CFR, Part 1910 Subpart S, Electrical.

1.3 SUBMITTALS FOR REVIEW/APPROVAL

- A. Furnish submittals as specified in Section 26 05 00 –General Requirements for Electrical Work.
- B. The initial short-circuit and protective device coordination studies shall be submitted to the design engineer prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment drawings for manufacturing. If formal completion of the studies may cause delay in equipment manufacturing, approval from the Engineer may be obtained for preliminary submittal of sufficient study data to ensure that the selection of device and characteristics will be satisfactory.

1.4 SUBMITTALS FOR CONSTRUCTION

- A. The final results of the short-circuit, protective device coordination and arc flash hazard analysis studies shall be summarized in a final report. No more than five (5) bound copies of the complete final report shall be submitted. For large system studies, submittals requiring more than five (5) copies of the report will be provided without the section containing the computer printout of the short-circuit input and output data. Additional copies, where required, shall be provided on CD in PDF format.
- B. The report shall include the following sections:
1. One-line diagram showing protective device ampere ratings and associated designations, cable size & lengths, transformer kVA & voltage ratings, motor & generator kVA ratings, and switchgear/switchboard/panelboard designations
 2. Descriptions, purpose, basis and scope of the study

3. Tabulations of the worst-case calculated short circuit duties as a percentage of the applied device rating (automatic transfer switches, circuit breakers, fuses, etc.); the short circuit duties shall be upward-adjusted for X/R ratios that are above the device design ratings
4. Protective device time versus current coordination curves with associated one line diagram identifying the plotted devices, tabulations of ANSI protective relay functions and adjustable circuit breaker trip unit settings
5. Multi-function relay setting file printouts including all ANSI protective relay functions and associated logic and control. Metering, communication, and control logic settings not associated with ANSI protective functions are not required.
6. Fault study input data, case descriptions, and current calculations including a definition of terms and guide for interpretation of the computer printout
7. Incident energy and flash protection boundary calculations
8. Comments and recommendations for system improvements, where needed
9. Executive Summary including source of information and assumptions made

1.5 QUALIFICATIONS

- A. The short-circuit, protective device coordination and arc flash hazard analysis studies shall be conducted under the supervision and approval of a Registered Professional Electrical Engineer skilled in performing and interpreting the power system studies. The Registered Professional Electrical Engineer shall be a full-time employee of the Engineering Services Organization.

PART 2 - PRODUCT

2.1 STUDIES

- A. Contractor to furnish short-circuit and protective device coordination studies as prepared by equipment manufacturer Engineer. By using the equipment manufacturer the study allows coordination of proper breakers, fuses, and current transformers. The coordination study shall begin with the utility company's feeder protective device and include all of the electrical protective devices down to and include the largest feeder circuit breaker and motor starter in the 480 Volt motor control centers and power distribution panelboards. The study shall also include variable frequency drives, harmonic filters, power factor correction equipment, transformers and protective devices associated with variable frequency drives, emergency and standby generators associated paralleling equipment and distribution switchgear.
- B. Perform studies using SKM Power Tools for Windows.
- C. Perform complete fault calculations for each source combination, which may include present and future power company supply circuits, large motors, or generators.

- D. Utilize data for study obtained from Contractor's field investigation of system configuration, wiring information, and equipment.
- E. Existing System and Equipment:
 - 1. Extent of existing system to be included in study is limited to system elements that affect new system and equipment.
 - 2. Include fault contribution of existing motors and equipment in study.
 - 3. Include impedance elements that affect new system and equipment.
 - 4. Include protective devices in series with new equipment.
- F. Device coordination time-current curves for low voltage distribution system; include individual protective device time-current characteristics.
- G. The Contractor shall furnish an Arc Flash Hazard Analysis Study per NFPA 70E - Standard for Electrical Safety in the Workplace, reference Article 130.5 and Informative Annex D.
- H. The short-circuit fault analysis shall be performed and submitted in 2 phases:
 - 1. Initial short-circuit fault analysis:
 - a. Based on the Contract Documents and Electric Utility information.
 - b. The initial short-circuit fault analysis report shall indicate the estimated available short-circuit current at the line side terminals of each piece of equipment covered by the scope of the study.
 - c. Provide a list of assumptions used in the initial study.
 - 2. Final short-circuit analysis:
 - a. The final short-circuit fault analysis shall modify the initial analysis as follows:
 - 1) Utilize the actual equipment provided on the project.
 - 2) Utilize conductor lengths based on installation.

2.2 DATA COLLECTION

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

- B. Data collection form information includes, but is not limited to, equipment types and nameplate data; all services and feeders including size and type of conductors, conduit types, and lengths; overcurrent protection device information including actual catalog numbers, ratings, and available trip settings; transformer information including type, connections, power ratings, and impedance; load nameplate data.
- C. Contractor to deliver completed data collection forms as specified herein to the Engineer 120 days prior to Project Substantial Completion to be utilized by the Engineer to develop a Power System Study Report.
- D. Source combination may include present and future utility supplies, motors, and generators.
- E. Load data utilized may include existing and proposed loads obtained from Contract Documents provided by Owner or Contractor.
- F. Include fault contribution of existing motors in the study, with motors < 50 hp grouped together. The Contractor shall obtain required existing equipment data, if necessary, to satisfy the study requirements.

2.3 SHORT-CIRCUIT AND PROTECTIVE DEVICE EVALUATION STUDY

- A. Prepare in accordance with IEEE 399.
- B. Use actual conductor impedances if known. If unknown, use typical conductor impedances based on IEEE Standards 141, latest edition.
- C. Use cable and bus resistances calculated at 25 degrees C.
- D. Use 5-kV and 600 volt cable reactances based on use of typical dimensions of specified conductors.
- E. Transformer design impedances and standard X/R ratios shall be used when test values are not available.
- F. Provide the following:
 - 1. Calculation methods and assumptions
 - 2. Selected base per unit quantities
 - 3. One-line diagram of the system being evaluated with available fault at each bus, and interrupting rating of devices noted
 - 4. Source impedance data, including electric utility system and motor fault contribution characteristics
 - 5. Zero-sequence impedance diagrams
 - 6. Typical calculations
 - 7. Tabulations of calculated quantities

8. Results, conclusions, and recommendations
- G. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each:
 1. Electric utility's supply termination point
 2. Incoming switchgear
 3. Low voltage switchgear
 4. Motor control centers
 5. Standby generators and automatic transfer switches
 6. Branch circuit panelboards
 7. Future load contributions as shown on one-line diagram.
 8. Other significant locations throughout the system
- H. For grounded systems, provide a bolted line-to-ground fault current study for areas as defined for the three-phase bolted fault short-circuit study.
- I. Protective Device Evaluation:
 1. Evaluate equipment and protective devices and compare to short circuit ratings
 2. Adequacy of switchgear, motor control centers, and panelboard bus bracing to withstand short-circuit stresses
 3. Adequacy of transformer windings to withstand short-circuit stresses
 4. Cable and busway sizes for ability to withstand short-circuit heating
 5. Notify Owner in writing, of existing, circuit protective devices improperly rated for the calculated available fault current

2.4 PROTECTIVE DEVICE COORDINATION STUDY

- A. Prepare in accordance with IEEE 242.
- B. Proposed protective device coordination time-current curves shall be graphically displayed on log-log scale paper.
- C. Provide separate curve sheets for phase and ground fault coordination for each scenario.
- D. Include on each curve sheet a complete title and one-line diagram with legend identifying the specific portion of the system covered.
- E. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.

- F. Apply motor protection methods that comply with NFPA 70.
- G. Identify device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
- H. Plot the following characteristics on the curve sheets, where applicable:
 - 1. Electric utility's protective device, relays, and fuses, including manufacturer's minimum melt, total clearing, tolerance, and damage bands
 - 2. Low voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands
 - 3. Low voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands
 - 4. Transformer full-load current at 100 percent, magnetizing inrush current, and ANSI transformer withstand parameters
 - 5. Conductor damage curves
 - 6. Significant symmetrical and asymmetrical fault currents
 - 7. Ground fault protective devices and device settings, as applicable
 - 8. Pertinent motor starting characteristics and motor damage points
 - 9. Motor overload relay settings for motors greater than 40 horsepower
 - 10. Pertinent generator short-circuit decrement curve and generator damage point
 - 11. Other system load protective devices for the largest branch circuit and the largest feeder circuit breaker in each motor control center
- I. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.
- J. Select each primary protective device required for a delta-wye connected transformer so that the characteristics or operating band is within the transformer parameters which includes a parameter equivalent to 58% of the ANSI withstand point to afford protection for secondary line-to-ground faults.
- K. Separate low voltage power circuit breakers from each other and the associated primary protective device by a 16% current margin for coordination and protection in the event of secondary line-to-line faults.
- L. Engineer shall provide settings file printouts for all multifunction relays supplied under this contract including all ANSI protective relay functions and associated logic and control. Metering, communication, and control logic settings not associated with ANSI protective functions are not required.

2.5 ARC FLASH HAZARD ANALYSIS

- A. Perform arc flash hazard study after short circuit and protective device coordination study has been completed, reviewed and accepted.
- B. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E-2012, Informative Annex D.
- C. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Alternative methods shall be presented in the proposal.
- D. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, panelboards, busway and splitters) where Work could be performed on energized parts.
- E. The Arc-Flash Hazard Analysis shall include all 480v locations and significant locations in 240 volt and 208 volt systems fed from transformers equal to or greater than 125 kVA.
- F. Safe working distances shall be specified for calculated fault locations based upon the calculated arc flash boundary considering an incident energy of 1.2 cal/cm².
- G. The Arc Flash Hazard analysis shall include calculations for maximum and minimum contributions of fault current magnitude. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume a minimum motor load. Conversely, the maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.
- H. Arc flash computation shall include both line and load side of main breaker calculations, where necessary.
- I. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584-2002 section B.1.2.

2.6 REPORT SECTIONS

- A. Input Data:
 - 1. Utility three-phase and line-to-ground available contribution with associated X/R ratios
 - 2. Short-circuit reactance of rotating machines with associated X/R ratios
 - 3. Cable type, construction, size, # per phase, length, impedance and conduit type
 - 4. Bus duct type, size, length, and impedance
 - 5. Transformer primary & secondary voltages, winding configurations, kVA rating, impedance, and X/R ratio

6. Reactor inductance and continuous ampere rating
 7. Aerial line type, construction, conductor spacing, size, # per phase, and length
- B. Short-Circuit Data:
1. Source fault impedance and generator contributions
 2. X to R ratios
 3. Asymmetry factors
 4. Motor contributions
 5. Short circuit kVA
 6. Symmetrical and asymmetrical fault currents
- C. Recommended Protective Device Settings:
1. Phase and Ground Relays:
 - a. Current transformer ratio.
 - b. Current setting.
 - c. Time setting.
 - d. Instantaneous setting.
 - e. Specialty non-overcurrent device settings.
 - f. Recommendations on improved relaying systems, if applicable.
 2. Circuit Breakers:
 - a. Adjustable pickups and time delays (long time, short time, ground).
 - b. Adjustable time-current characteristic.
 - c. Adjustable instantaneous pickup.
 - d. Recommendations on improved trip systems, if applicable.
- D. Incident energy and arc flash boundary calculations.
1. Arcing fault magnitude
 2. Device clearing time
 3. Duration of arc

4. Flash hazard protection boundary.
 5. Limited approach boundary.
 6. Restricted approach boundary.
 7. Prohibited approach boundary.
 8. Incident energy level.
 9. Personal protection equipment (PPE) hazard/risk category.
 10. Type of PPE required.
 11. Recommendations for arc flash energy reduction
- E. Analyze short circuit, protective device coordination, and arc flash calculations and highlight equipment that is determined to be underrated or causes incident energy values greater than 8 cal/cm². Propose approaches to reduce energy levels
- F. Prepare report summarizing arc flash study with conclusions and recommendations which may affect integrity of electric power distribution system. As a minimum, include the following:
1. Equipment manufacturer's information used to prepare study.
 2. Assumptions made during study.
 3. Copy of one-line drawing.
 4. Arc flash evaluations summary spreadsheet.
 5. Bus detail sheets.
 6. Arc flash warning labels printed in color on adhesive backed labels.

2.7 ARC FLASH WARNING LABELS

- A. Arc flash labels shall be provided in the following manner and all labels shall be based on recommended overcurrent device settings.
1. For each 480 and applicable 208 volt panelboards and disconnects, one arc flash label shall be provided
 2. For each motor control center, one arc flash label shall be provided
 3. For each low voltage switchboard, one arc flash label shall be provided
 4. For each switchgear, one flash label shall be provided
 5. Labels shall be machine printed, with no field markings

- B. The label shall have an orange header with the wording, “WARNING, SHOCK & ARC FLASH HAZARD”, and shall include the following information:
 - 1. Location designation
 - 2. Nominal voltage
 - 3. Flash hazard protection boundary
 - 4. Limited approach boundary.
 - 5. Restricted approach boundary.
 - 6. Prohibited approach boundary.
 - 7. Incident energy level.
 - 8. Personal protection equipment (PPE) hazard/risk category.
 - 9. Type of PPE required.
 - 10. Engineering report number, revision number and issue date
- C. The Engineer will provide the Contractor adhesive backed labels for installation by Contractor or field installed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.

2.8 DATA COLLECTION FORMS

- A. Examples of data collection forms are located following end of section. Contractor shall coordinate with the Engineer if collection form modifications are required to accommodate differing circumstances or unlisted equipment.

PART 3 - EXECUTION

3.1 ELECTRICAL SYSTEM STUDY MEETINGS

- A. The individual conducting the short circuit analysis, protective device coordination, and the arc-flash hazard studies shall meet with the Owner and Engineer 3 times.
- B. The purpose of the 3 meetings is as follows:
 - 1. Initial meeting:
 - a. Meet with the Owner and Engineer to discuss the scope of the studies.
 - b. Discuss the Owner’s operational requirements for both normal operation and maintenance.
 - 2. Preliminary results meeting:

- a. This meeting will be held after the studies have been completed, reviewed, and accepted by the Engineer.
- b. The purpose of this meeting is to inform the Owner of the results of the study and impacts on normal operation and maintenance including:
 - 1) Protective device coordination problems and recommended solutions.
 - 2) Explanation of the arc-flash study results and its potential impact on operations.
 - 3) Recommendations for reduction of arc-flash category levels including reduction of protective device settings or changes in operational practices.
3. Final meeting:
 - a. Discuss changes to the reports based on the previous meeting.
 - b. Discuss with the Owner how changes to the electrical system may change the arc-flash hazard category.
 - c. Deliver the final electrical system studies report.
- C. The meetings will be at the Owner's facility:
 1. Provide a minimum of 3 weeks notice to the Owner and Engineer in advance of the projected meeting date.
 2. Submit a draft of the meeting agenda when each meeting is requested.
- D. Meeting materials:
 1. Prepare and provide the following materials:
 - a. Meeting agenda. Include at a minimum the scope of the meeting, estimated time length for the meeting and meeting goals.
 - b. 6 copies of the Project one-line diagrams for the initial meeting.
 - c. 6 copies of the studies of the submitted study.
- E. By virtue of the fact that this is a professional study the Owner reserves the right to modify the requirements of the study to comply with its operational requirements. The protective device coordination study and the arc-flash study shall be modified based on the results of the meetings with the Owner.

3.2 FIELD ADJUSTMENT

- A. Adjust relay and protective device settings according to the recommended settings table provided by the coordination study. Field adjustments to be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.
- B. Make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.
- C. Notify Owner in writing of any required major equipment modifications.
- D. Following completion of all studies, acceptance testing and startup by the field engineering service division of the equipment manufacturer, a 2-year warranty shall be provided on all components manufactured by the engineering service parent manufacturing company.

3.3 ARC FLASH TRAINING

- A. The equipment vendor shall train personnel of the potential arc flash hazards associated with working on energized equipment (minimum of 4 hours). Maintenance procedures in accordance with the requirements of NFPA 70E, Standard For Electrical Safety Requirements For Employee Workplaces, shall be provided in the equipment manuals. The training shall be certified for continuing education units (CEUs) by the International Association for Continuing Education Training (IACET).

3.4 SUPPLEMENTS

- A. The supplement listed below, following “End of Section,” is a part of this Specification:
 - 1. Data collection form – Panelboard.
 - 2. Data collection form – Medium Voltage MCC (motor controller unit).
 - 3. Data collection form – Medium Voltage MCC (main circuit breaker).
 - 4. Data collection form - Low Voltage MCC (main circuit breaker).
 - 5. Data collection form – Low Voltage MCC (feeder circuit breaker or motor controller unit).
 - 6. Data collection form – Reduced Voltage Motor Starter (circuit breaker).
 - 7. Data collection form – Dry Type Transformer.

END OF SECTION 26 05 73

**DATA COLLECTION FORM
MEDIUM VOLTAGE MCC (MOTOR CONTROL UNIT)**

MCC ID OR TAG #:

MOTOR PROTECTOR RELAY MANUFACTURER:

MOTOR STARTER UNIT PART #:

STARTER FUSE SIZE:

STARTER FUSE TYPE:

MOTOR PROTECTOR RELAY PART #:

PHASE OVERCURRENT SETTING:

GROUND OVERCURRENT SETTING:

PHASE UNBALANCE SETTING:

GROUND FAULT OVERVOLTAGE SETTING:

FREQUENCY SETTINGS:

OTHER SETTINGS:

LOAD SERVED:

LOAD ID OR TAG #

LOAD SIZE AND TYPE

WIRE SIZE TO LOAD:

NUMBER OF PARALLEL RUNS:

WIRE LENGTH:

CONDUIT SIZE(S):

NOTES:

**DATA COLLECTION FORM
MEDIUM VOLTAGE MCC (MAIN CIRCUIT BREAKER)**

MCC ID OR TAG #:

CIRCUIT BREAKER MANUFACTURER AND PART #:

CURRENT RATING:

ANSI INTERRUPTING RATING:

PROTECTIVE RELAY SETTINGS:

PHASE OVERCURRENT:

GROUND OVERCURRENT:

GROUND FAULT OVERVOLTAGE

MAIN 3-PHASE UNDER/OVER VOLTAGE:

PHASE UNBALANCE SETTINGS:

FREQUENCY SETTINGS:

OTHER MISC SETTINGS:

WIRE SIZE FROM SOURCE:

NUMBER OF PARALLEL RUNS:

WIRE LENGTH:

CONDUIT SIZE(S):

NOTES:

**DATA COLLECTION FORM
LOW VOLTAGE MCC (MAIN CIRCUIT BREAKER)**

MCC ID OR TAG #:

FED FROM (SOURCE):

MCC MANUFACTURER:

MCC PART #:

VOLTAGE:

SHORT CIRCUIT CURRENT RATING (SSCR):

CIRCUIT BREAKER MANUFACTURER AND PART #:

FRAME SIZE:

INTERRUPTING RATING:

ADJUSTABLE MAGNETIC PICKUP:

RATING PLUG:

TRIP UNIT PROTECTIVE PROGRAMMER MANUFACTURER AND PART NUMBER:

ARC FLASH REDUCTION MAINTENANCE SYSTEM MANUFACTURER AND PART NUMBER:

WIRE SIZE FROM SOURCE:

NUMBER OF PARALLEL RUNS:

WIRE LENGTH:

CONDUIT SIZE(S):

DATA COLLECTION FORM
LOW VOLTAGE MCC (FEEDER CIRCUIT BREAKER OR MOTOR CONTROLLER UNITS)

MCC ID OR TAG #:

FEEDER BREAKER MANUFACTURER AND PART #:

FRAME SIZE:

INTERRUPTING RATING:

ADJUSTABLE MAGNETIC PICKUP:

CIRCUIT BREAKER RATING PLUG:

TRIP UNIT PROTECTIVE PROGRAMMER MANUFACTURER AND PART NUMBER:

ARC FLASH REDUCTION MAINTENANCE SYSTEM MANUFACTURER AND PART NUMBER:

MOTOR STARTER UNIT PART #:

MOTOR STARTER SIZE:

OVERLOAD RELAY SETTING (>40HP):

ADDITIONAL MOTOR STARTER INFO:

LOAD SERVED:

LOAD ID OR TAG #:

LOAD NAMEPLATE DATA AND TYPE:

WIRE SIZE TO LOAD:

NUMBER OF PARALLEL RUNS:

WIRE LENGTH:

CONDUIT SIZE(S):

NOTES:

DATA COLLECTION FORM
480-V REDUCED VOLTAGE MOTOR STARTER (CIRCUIT BREAKER)

MOTOR STARTER ID OR TAG #:

CIRCUIT BREAKER MANUFACTURER AND PART #:

FRAME SIZE:

INTERRUPTING RATING:

ADJUSTABLE MAGNETIC PICKUP:

MOTOR STARTER UNIT PART #:

MOTOR STARTER SIZE AND TYPE:

OVERLOAD RELAY SETTINGS:

ADDITIONAL MOTOR STARTER INFO:

LOAD SERVED:

LOAD ID OR TAG #:

LOAD NAMEPLATE DATA AND TYPE:

WIRE SIZE TO LOAD:

NUMBER OF PARALLEL RUNS:

WIRE LENGTH:

CONDUIT SIZE(S):

NOTES:

**DATA COLLECTION FORM
DRY-TYPE TRANSFORMER**

TRANSFORMER ID OR TAG #:

FED FROM:

MANUFACTURER:

NAMEPLATE DATA:

PRIMARY VOLTAGE:

PRIMARY CONNECTION (DELTA OR WYE-GND):

SECONDARY VOLTAGE:

SECONDARY CONNECTION (WYE-GND):

IMPEDANCE:

PRIMARY TAP SETTING:

PRIMARY WIRE SIZE:

PRIMARY WIRE LENGTH:

PRIMARY CONDUIT SIZE:

SECONDARY WIRE SIZE:

SECONDARY WIRE LENGTH:

SECONDARY CONDUIT SIZE:

NOTES:

SECTION 26 05 84 - ELECTRIC MOTORS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section applies only when referenced by a motor-driven equipment specification for alternating current induction motors. This Section does not specify specialty motors such as hoist motors, valve operator motors, DC motors, or torque rated motors. Specialty motors are specified in the individual equipment specification(s).

1.2 REFERENCES

Reference	Title
ABMA 9	Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	Load Ratings and Fatigue Life for Roller Bearings
IEEE 112	Standard Test Procedures for Polyphase Induction Motors and Generators
IEEE 841	Standard for Petroleum and Chemical Industry-Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors - Up to and Including 500 HP
NEMA ICS	Industrial control and systems controllers, contactors and overload relays rated 600 volts
NEMA 250	Enclosures for Electrical Equipment (1000 volts maximum)
NEMA MG 1	Motors and Generators
NEMA MG1-30	Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable- Frequency Controls or Both
NEMA MG1-31	Definite-Purpose Inverter-Fed Polyphase Motors: Rated 5000 horsepower or less at 7200 volt or less, intended for use with adjustable-voltage and adjustable frequency controls, commonly referred to as inverters.
UL 674	Electric Motors and Generators for Use in Hazardous (Classified) Locations
UL 1004	Electric Motors

1.3 SUBMITTALS

- A. Action Submittal Items:
1. Provide a separate motor data form for each motor of 1/2 horsepower and greater.
 2. Descriptive information.

3. Motor outline, dimensions and weight.
4. Where a winding over-temperature device is specified for motors 100 horsepower or larger, provide a response curve for the temperature device.
5. Motor nameplate data in accordance with NEMA MG1.
6. Additional Rating Information:
 - a. Service factor
 - b. Locked rotor current.
 - c. No load current.
 - d. Safe stall time for motors 250 HP and larger.
 - e. Multispeed load classification (e.g. variable torque).
7. Enclosure type and mounting (e.g. horizontal, vertical),
8. Dimensions and total weight.
9. Conduit box dimensions and usable volume as defined in NEMA MG 1 and NFPA 70.
10. Bearing type.
11. Bearing lubrication.
12. Bearing life.
13. Space heater voltage and watts.
14. Description and rating of motor thermal protection.
15. Motor sound power level in accordance with NEMA MG 1.
16. Maximum break horsepower required by the equipment driven by the motor.
17. Description and rating of immersible/submersible motor moisture sensing system.
18. For inverter duty motors:
 - a. Inverter duty motor specs including the motor winding voltage rating.
 - b. Circuit distance in feet that the motor will be located from the drives.
 - c. Variable or constant torque application.
 - d. Operating speed range.

- e. Motor manufacturer's statement that the submitted motor is fully suitable for operation with the selected variable frequency drive.

1.4 SERVICE REQUIREMENTS

- A. All equipment shall be designed and built for industrial service and be capable of delivering rated horsepower under the following conditions:
 - 1. 100 degrees F maximum ambient temperature.
 - 2. 100 percent relative humidity.
 - 3. Voltage variations to ± 10 percent of nameplate rating.
 - 4. Frequency variations to ± 5 percent of nameplate rating.
 - 5. Combined voltage and frequency variations to ± 10 percent total, as long as frequency does not exceed ± 5 percent.
 - 6. Motors shall be suitable for operating conditions and load classification without any reduction being required in the nameplate rated horsepower or exceeding the rated temperature rise.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Provide all motors in accordance with NEMA MG 1, UL 674, UL 1004, the requirements specified in this Section, and the individual equipment specification. Motors shall be the manufacturer's standard industrial product. Additional or better features which are not specifically prohibited by the specifications, but which are a part of the manufacturer's standard industrial product, shall be included in the furnished motor. A standard industrial product is a product that has been or will be sold on the market through advertisement or manufacturer's catalogs/brochures, and represents the latest production model(s).
- B. Motor enclosure, rpm, horsepower, and modifications (if any) are specified in the individual equipment specification.
- C. Two-speed motors shall be two-winding motors. Two-speed, one-winding consequential-pole motors are prohibited.
- D. Factory mount motors to the equipment when practicable.
- E. Motor Enclosures:
 - 1. ODP: Open Drip Proof, NEMA MG1.25.1.
 - 2. TEFC: Totally Enclosed, Fan Cooled, NEMA MG1.26.2, IEEE 841.
 - 3. XP: Explosion Proof, NEMA MG1.26.10.

- F. Electrical Requirements (unless the individual equipment specification indicates otherwise):
1. Service factor:
 - a. Single-phase motors: 1.0.
 - b. Service factor for three-phase motors: 1.15.
 - c. Inverter duty motors: 1.0.
 2. Time rating: continuous in conformance with NEMA MG 1 10.35.
 3. Torques: meet, or exceed, the locked rotor and breakdown torques specified for NEMA Design B.
 4. Currents: locked rotor currents not to exceed NEMA Design B values.
 5. Protection: current density and heating characteristics shall be such that the motors will not burn out if subjected to a maximum of 20-second stall at 6 times full-load current.
 6. Rating: not allowed to operate at greater than their nameplate horsepower. Use of the service factor will not be allowed under conditions of rated voltage and frequency.
 7. Insulation: non-hydroscopic insulation systems conforming to the requirements for NEMA Class B or higher.
 8. Box: one size larger than standard.
- G. Mechanical Requirements (unless the individual equipment specification indicates otherwise):
1. Frame sizes: Conforming to latest NEMA Standard MG1-11.31 for "T" frames, and all dimensions meeting NEMA Standards insofar as they apply.
 2. Shafts:
 - a. In accordance with NEMA "T" or "TS" dimensions.
 - b. Long shafts: Suitable for belt, chain, or gear drive, within limits established by good industrial practice and documented by NEMA Standards MG1-14.42 and MG1-14.07.
 - c. Short shafts: Used for direct connection.
 - d. Provisions for mounting of shaft grounding brushes on variable speed motors where required by these specifications.
 3. Connection diagrams: Permanently attached to the motor, either inside the box or on the motor frame, in a location readable from the box side.

4. Stainless steel bolts, screws, and other external hardware.
- H. Nameplates:
1. Engraved or stamped stainless steel.
 2. Fastened to the motor frame with screws or drive pins of the same material.
 3. Nameplates shall indicate clearly all the items of information enumerated in NEMA MG1.
 4. Coordinate the motor nameplate location so it is readily visible for inspection on the completed machine.
- I. Protective Coating: Before shipment, coat the shaft extension and any other external bare exposed metal parts of each motor with an easily removable rust preventive coat.
- J. Packaging: All loose motors shall be packed in Styrofoam or securely fastened to a hardwood skid or pallet for fork-truck handling and shall be covered for protection against dirt and moisture during transit and for short-time outdoor storage.

2.2 VOLTAGE AND FREQUENCY RATING

- A. System Frequency: 60-Hz.
- B. Voltage Rating: Unless otherwise indicated in motor driven equipment specifications:

Size	Voltage	Phases
1/2 HP and smaller	115	1
3/4 HP through 500 HP	460	3
600 HP and larger	4,000	3

- C. Suitable for full voltage starting. 100HP and larger also suitable for reduced voltage starting.
- D. Suitable for accelerating the connected load with supply voltage at motor starter supply terminals dipping to 90 percent of motor rated voltage.

2.3 MOTORS LESS THAN ½ HORSEPOWER

- A. Dual voltage (115/230) rated motors are acceptable if all leads are brought out to the box. Motors shall include integral overload protection per NEC Article 430 or shall include an external manual motor starter installed as required to provide overload protection.

2.4 MOTORS ½ THROUGH 800 HP

- A. Open Drip-Proof (ODP) Motor:
1. Class F insulation with Class B temperature rise.

2. Comply with the minimum nameplate efficiency in NEMA MG 1. Determine Efficiency by the dynamometer test method, IEEE 112, Method B.
 3. Candidate Manufacturers:
 - a. General Electric Inc., Type KS, Premium Efficiency
 - b. Emerson US Motor, Type DE or RE, Premium Efficiency
 - c. Approved Equal
- B. Totally Enclosed Fan Cooled (TEFC):
1. Having a Class F insulation with Class B temperature rise.
 2. Comply with the minimum nameplate efficiency in NEMA MG 1. Determine efficiency by the dynamometer test method, IEEE 112, Method B.
 3. Internal surfaces coated with a corrosion-resistant epoxy paint.
 4. Severe duty rated conforming to IEEE 841 guidelines.
 5. Inverter duty rated for application on variable frequency drives as specified in this Section.
 6. Furnish enclosure with drain hole with porous drain/weather plug.
 7. Candidate Manufacturer:
 - a. General Electric IEEE 841, XSD, Severe Duty
 - b. Reliance Electric IEEE 841, XL, Severe Duty
 - c. Approved Equal
- C. Explosion Proof (XP) Motor:
1. UL 674 listed for Class I, Division 1, Group D hazardous atmospheres.
 2. Class F insulation.
 3. UL approved breather/drain device provided in the motor drain hole.
 4. Provided with a frame temperature thermostat which does not exceed the UL frame temperature limit code T2A (280 degrees C).
 5. Thermostat containing an automatically reset, normally closed contact rated 2A at 115 VAC. Thermostat leads to terminate in a terminal box separate from main terminal box.
 6. The nameplate marked with a maximum UL temperature limit code T2A.

7. Comply with the minimum nameplate efficiency in NEMA MG 1-2011. Determine efficiency by the dynamometer test method, IEEE 112, Method B.
 8. Candidate manufacturers:
 - a. General Electric Type KS, Explosion Proof, Premium Efficiency
 - b. Reliance Electric Type XP-XEX, IP54 with temperature code T3C, Premium Efficiency
 - c. Emerson US Motor, Type LCE, Premium Efficiency
 - d. Approved Equal.
- D. Immersible/Submersible Motors:
1. UL approved for explosion proof atmospheres in accordance with this Section.
 2. Having two mechanical seals, a lower one which is outside the motor and protecting the upper one which is in an oil-filled chamber.
 3. Winding Thermal Protection:
 - a. Thermal sensor and switch assembly, one each phase, embedded in stator windings and wired in series.
 - b. Switches normally closed, open upon excessive winding temperature, and automatically reclose when temperature has cooled to safe operating level.
 - c. Switch contacts rated at 5 amps, 120 volts ac.
 - d. Fractional horsepower, 115 volts ac, single-phase units: Switch shall be connected in series with winding for direct thermal protection interlock.
 4. Moisture Seal Failure Moisture Detection:
 - a. Moisture detector probes in the oil-filled seal chamber shall be provided to indicate the presence of moisture in the seal chamber.
 - b. A normally closed NEMA Class B150 contact from the moisture detector shall open to deactivate the motor control circuit in the event of moisture detection.
 - c. Probe or sensor monitoring module shall be provided suitable for mounting in a terminal junction box and shall be suitable for operation from 120 volt ac supply.
 - d. Monitoring module shall include two independent 120 volt ac contacts, one opening and one closing when moisture is detected.
 5. Provide required relays or solid state controls in an enclosure on or near the motor.

6. Connecting cables:
 - a. One cable containing power, control, and grounding conductors.
 - b. Suitable for hard service, submersible duty with watertight seal where cable enters motor.
 - c. Length: 30 feet minimum.
 - d. UL 1 listed and sized in accordance with NFPA 70.
7. Efficiencies as specified in the individual equipment specification.
- E. Vertical Motors: full voltage with a Type P base.
- F. Inverter Duty Motors:
 1. Motors for use with variable frequency drives shall be inverter duty motors specifically designed for inverter service for the speed range and load torque characteristic required by the associated equipment. Motor manufacturer shall certify motor is compatible with the proposed variable frequency drives and associated equipment.
 2. Motors for use with variable frequency drives shall not exceed NEMA MG 1, Class B temperature rise when operating over the specified speed range on the specified adjustable frequency controllers with the specified load speed/torque characteristic.
 3. Inverter duty rated motors shall have 4:1 turndown with variable torque motor controllers or constant torque motor controllers rating designed to operate from 25 percent of base speed to base speed continuously with full load current and torque without exceeding the Class F insulation with B temperature rise.
 4. Torque requirement for greater turndown and slower speed applications is a custom design; refer to the individual equipment specification for additional requirements. Inverter duty rated motors shall be designed to operate over the speed or frequency range specified.
 5. Motor insulation shall be designed to meet or exceed the 1600V peak at a minimum of 0.1 microsecond rise time per NEMA MG 1, Part 31.
 6. Provide inverter duty motors with over-temperature protection. Motor over temperature protection for inverter duty motors up to and including 250 horsepower shall be NEMA Type 2 as specified in NEMA MG 1-12, via bimetallic thermal switches (Klixons) embedded in the motor windings. Over-temperature protection for larger motors to 500 horsepower shall be with 100-ohm platinum RTDs embedded in the motor windings, two per phase.

7. Inverter duty motors shall have electrically insulated bearings or shall be equipped with a shaft-grounding unit mounted on the fan housing with stub shaft extended from the motor shaft. The shaft-grounding unit shall be equipped with two brushes, totally enclosed, and sealed against environmental contamination.

2.5 BEARINGS AND LUBRICATION

A. Horizontal motors:

1. $\frac{3}{4}$ HP and Smaller: Permanently lubricated and sealed ball bearings, or regreasable ball bearings in labyrinth sealed end bells with removable grease relief plugs.
2. 1 through 400 HP: Regreasable ball bearings in labyrinth sealed end bells with removable grease relief plugs.
3. Above 400 HP: Regreasable antifriction bearings in labyrinth sealed end bells with removable grease relief plugs.
4. Minimum 100,000 hours L-10 bearing life for ball and roller bearings as defined in ABMA 9 and 11.

B. Vertical Motors:

1. Thrust Bearings:
 - a. Antifriction bearing.
 - b. Manufacturer's standard lubrication 100 HP and smaller.
 - c. Oil lubricated 125 HP and larger.
 - d. Minimum 50,000 hours L-10 life.
2. Guide Bearings:
 - a. Manufacturer's standard bearing type.
 - b. Manufacturer's standard lubrication 200 HP and smaller.
 - c. Oil lubricated 250 HP and larger.
 - d. Minimum 100,000 hours L-10 bearing life.

C. Regreasable Antifriction Bearings:

1. Readily accessible, grease injection fittings.
2. Readily accessible, removable grease relief plugs.

D. Oil Lubrication Systems:

1. Oil reservoirs with sight level gauge.

2. Oil fill and drain openings with opening plugs.
3. Provisions for necessary oil circulation and cooling.

2.6 ACCESSORIES

A. Connection Boxes

1. Provided with threaded hubs.
2. Provide neoprene gaskets at the base of the box and between the halves of the box.
3. Provide a grounding lug within the box for a cable or raceway ground connection.
4. Boxes shall be designed to rotate in order to permit installation in any of four positions 90 degrees apart.
5. Provide oversized boxes, a minimum of one size larger than standard.

B. Temperature Protection:

1. Constant speed, ODP, and TEFC motors above 300 horsepower:
 - a. 100-ohm platinum RTDs, two per phase embedded in each winding phase.
 - b. RTD wiring brought out to a separate control terminal box mounted on the motor.
2. Non-explosion proof motors from 25 horsepower up to and including 300 horsepower:
 - a. Having a NEMA Type 1 temperature sensing device embedded in the motor winding which is sensitive to both motor running over temperature and with fast response to rate of temperature rise for locked rotor protection.
 - b. Sensor: wired to a NEMA 4 temperature monitor box located near or on the motor.
 - c. Temperature Sensing System: manual reset, normally closed contact, rated 2A at 115 VAC.
 - d. Mark motor nameplate "OVER TEMP PROT 1" in accordance with NEMA MG 1 12.53.
3. When specified in the individual equipment specification, provide for 10, 15 and 20 horsepower constant speed, non-explosion proof motors:
 - a. NEMA Type 2 bi-metallic thermal switch (Klixon) type.
 - b. Mark motor nameplate "OVER TEMP PROT 2" in accordance with NEMA MG 1 12.53.

C. Space Heater:

1. When specified in the individual equipment specification, provide space heater to maintain the winding temperature at not less than 5-degrees C above ambient during motor shutdown.
2. Provide flexible wraparound type heater rated 120V, single phase, 60 Hz; note rating in watts and volts on the motor nameplate or on a second nameplate. Bring heater leads H1 and H2 to a separate box with a threaded conduit opening.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Refer to the Standard Details for motor grounding requirements.

3.2 COMPONENT TEST PHASE

- A. Verify breather/drain fittings installed as specified in the Construction Documents.
- B. Motor winding insulation resistance shall not be less than 10-megohm, measured with a 1000 VAC megohm meter at 1-minute at or corrected to 40 degrees C.
- C. For motors 50 horsepower and larger, perform motor phases current imbalance testing in accordance with Section 26 08 00 – Commissioning of Electrical Systems.

END OF SECTION 26 05 84

SECTION 26 08 00 – COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Responsibilities for testing the electrical installation.
2. Routine tests during installation.
3. Adjusting and calibration.
4. Acceptance tests.
5. Demonstration of electrical equipment.
6. Commissioning and plant start-up.

B. Related sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 26 05 00 – General Requirements for Electrical Work
 - b. Section 26 05 26 – Grounding and Bonding for Electrical Systems

C. Copyright information:

1. Some portions of this Section are copyrighted by the InterNational Electrical Testing Association, Inc (NETA). See NETA publication ATS for details.

1.2 REFERENCES

- A. As specified in Section 26 05 00 – General Requirements for Electrical Work.
- B. American National Standards Institute (ANSI).
- C. ASTM International (ASTM):

1. D 877 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
 2. D 923 - Standard Practices for Sampling Electrical Insulating Liquids.
 3. D 971 - Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method.
 4. D 1298 - Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
 5. D 1500 - Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale).
 6. D 1524 - Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field.
 7. D 1816 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using VDE Electrodes.
 8. D 3612 - Standard Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography.
- D. Institute of Electrical and Electronics Engineers (IEEE):
1. 43 - IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
 2. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.
 3. 95 - IEEE Recommended Practice for Insulation Testing of AC Electric Machinery (2300 V and Above) With High Direct Voltage.
 4. 450 - IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.
 5. C2 - National Electric Code.
 6. C37.20.1 - Standard for Metal-Enclosed Low Voltage Power Circuit Breaker Switchgear.
 7. C57.13 - IEEE Standard Requirements for Instrument Transformers.
 8. C57.13.1 - IEEE Guide for Field Testing of Relaying Current Transformers.
 9. C57.13.3 - IEEE Guide for Grounding of Instrument Transformer Secondary Circuits and Cases.
 10. C57.104 - IEEE Guide for the Interpretation of Gases Generated in Oil-Immersed Transformers.

11. C62.33 - Standard Test Specification for Varistor Surge-Protective Devices.
 - E. National Electrical Manufacturers Association (NEMA):
 1. AB 4 - Guidelines for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications.
 2. PB 2 - Deadfront Distribution Switchboards.
 - F. Insulated Cable Engineer's Association (ICEA).
 - G. InterNational Electrical Testing Association (NETA).
 1. AT5-2009 Standard for Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems.
 - H. International Electrotechnical Commission (IEC).
 - I. Manufacturer's testing recommendations and instruction manuals.
 - J. National Fire Protection Association (NFPA):
 1. 70 - National Electrical Code (NEC).
 2. 70B - Recommended Practice for Electrical Equipment Maintenance.
 3. 70E - Standard for Electrical Safety in the Workplace.
 4. 101 - Life Safety Code.
 5. 110 – Standard for Emergency and Standby Power Systems.
 - K. National Institute of Standards and Technology (NIST).
 - L. Occupational Safety and Health Administration (OSHA):
 1. CFR 29, Part 1910 - Occupational Safety and Health Standards.
 - M. Specification sections for the electrical equipment being tested.
 - N. Shop drawings.
- 1.3 DEFINITIONS
- A. As specified in Section 26 05 00 – General Requirements for Electrical Work.
 - B. Specific definitions:
 1. Testing laboratory: The organization performing acceptance tests.

1.4 SYSTEM DESCRIPTION

- A. Testing of all electrical equipment installed under this Contract in accordance with the manufacturer's requirements and as specified in this Section.
- B. Conduct all tests in the presence of the Engineer or the Engineer's representative:
 - 1. The Engineer will witness all visual, mechanical and electrical tests and inspections.
- C. The testing and inspections shall verify that the equipment is operational within the tolerances required and expected by the manufacturer, and these Specifications. The results of the tests shall determine the suitability for continued reliable operation.
- D. Perform inspection and testing in accordance with NETA ATS, industry standards, and manufacturer's recommendations.
- E. Responsibilities:
 - 1. Contractor responsibilities:
 - a. Ensure that all resources are made available for testing, and that all testing requirements are met.
 - 2. Electrical subcontractor responsibilities:
 - a. Perform routine tests during installation.
 - b. Demonstrate operation of electrical equipment.
 - c. Commission the electrical installation.
 - d. Provide the necessary services during testing, and provide these services to the testing laboratory, Contractor, and other subcontractors, including but not limited to:
 - 1) Providing electrical power as required.
 - 2) Operating of electrical equipment in conjunction with testing of other equipment.
 - 3) Activating and shutting down electrical circuits.
 - 4) Making and recording electrical measurements.
 - 5) Replacing blown fuses.
 - 6) Installing temporary jumpers.

3. Testing laboratory responsibilities:
 - a. Perform all acceptance tests as defined in this Section.
 - b. Provide all required equipment, materials, labor, and technical support during acceptance tests.
- F. Upon completion of testing or calibration, attach a label to all serviced devices:
 1. The label shall indicate the date serviced and the company that performed the service.

1.5 SUBMITTALS

- A. Furnish submittals as specified in Section 26 05 00 – General Requirements for Electrical Work.
- B. Informational Submittals:
 1. Submit 30 days prior to performing inspections or tests:
 - a. Schedule for performing inspection and tests.
 - b. List of references to be used for each test.
 - c. Sample copy of equipment and materials inspection form(s).
 - d. Sample copy of individual device test form.
 - e. Sample copy of individual system test form if different from.
 2. Energization Plan: Prior to initial energization of electrical distribution equipment; include the following:
 - a. Owner's representative sign-off form for complete and accurate arc flash labeling and proper protective device settings for equipment to be energized.
 - b. Staged sequence of initial energization of electrical equipment.
 - c. Lock-Out-Tag-Out plan for each stage of the progressive energization.
 - d. Barricading, signage, and communication plan notifying personnel of newly energized equipment.
 3. Submit test or inspection reports and certificates for each electrical item tested within 30 days after completion of test:
 4. Operation and Maintenance Data:
 - a. In accordance with Project Specifications.

- b. After test or inspection reports and certificates have been reviewed by Engineer and returned, insert a copy of each in Operation and Maintenance Manual.
 - 5. Programmable Settings: At completion of Performance Demonstration Test, submit final hardcopy printout and electronic files on compact disc of as-left set points, programs, and device configuration files for:
 - a. Protective relays
 - b. Intelligent overload relays.
 - c. Variable frequency drives.
 - d. Power metering devices.
- C. LAN cable test form:
 - 1. LAN cable test reports:
 - a. Submit 3 copies of test reports showing the results of all tests specified in this Section:
 - 1) Test type.
 - 2) Test location.
 - 3) Test date.
 - 4) Cable number.
 - 5) Cable length.
 - 6) Certification that the cable meets or exceeds the specified standard.
 - b. Furnish hard copy and electronic copy for all traces.
- D. Test report:
 - 1. Include the following:
 - a. Summary of Project.
 - b. Description of equipment tested.
 - c. Description of tests performed.
 - d. Test results.
 - e. Conclusions and recommendations.

- f. Completed test forms.
 - g. List of test equipment used and calibration dates.
 - h. LAN cable test reports.
- E. Testing laboratory qualifications:
- 1. Submit a complete resume and statement of qualifications from the proposed testing laboratory detailing their experiences in performing the tests specified:
 - a. This statement will be used to determine whether the laboratory is acceptable, and shall include:
 - 1) Corporate history and references.
 - 2) Resume of individual performing test.
 - 3) Equipment list and test calibration data.
- F. Energization Plan: Prior to initial energization of electrical distribution equipment, include the following:
- 1. Owner's representative sign-off form for complete and accurate arc flash labeling and proper protective device settings for equipment to be energized.
 - 2. Staged sequence of initial energization of electrical equipment.
 - 3. Lock-Out-Tag-Out plan for each stage of the progressive energization.
 - 4. Barricading, signage, and communication plan notifying personnel of newly energized equipment.
- G. Operation and Maintenance Data:
- 1. In accordance with Project Specifications.
 - 2. After test or inspection reports and certificates have been reviewed by Engineer and returned, insert a copy of each in Operation and Maintenance Manual.
- H. Programmable Settings: At completion of Performance Demonstration Test, submit final hardcopy printout and electronic files on compact disc of as-left set points, programs, and device configuration files for:
- 1. Protective relays
 - 2. Intelligent overload relays.
 - 3. Variable frequency drives.
 - 4. Power metering devices.

- I. Division of responsibilities:
 - 1. Submit a list identifying who is responsible for performing each portion of the testing.
- J. Manufacturers' testing procedures:
 - 1. Submit manufacturers' recommended testing procedures and acceptable test results for review by the Engineer.

1.6 QUALITY ASSURANCE

- A. As specified in Section 26 05 00 – General Requirements for Electrical Work.
- B. Testing laboratory qualifications:
 - 1. The testing laboratory may be qualified testing personnel from the electrical subcontractor's staff or an independent testing company.
 - 2. Selection of the testing laboratory and testing personnel is subject to approval by the Engineer based on testing experience and certifications of the individuals and testing capabilities of the organization.
 - 3. Supervising engineer must be accredited as Certified Electrical Test Technologist by NICET or NETA and having a minimum of 5 years' testing experience on similar projects.
 - 4. Technicians must be certified by NICET or NETA.
 - 5. Assistants and apprentices assigned to Project at ratio not to exceed two certified to one noncertified assistant or apprentice.
 - 6. Laboratory must be in compliance with OSHA CFR 29, Part 1910.7 criteria for accreditation of testing laboratories or a full member company of NETA.

1.7 PROJECT OR SITE CONDITIONS

- A. As specified in Section 26 05 00 – General Requirements for Electrical Work.

1.8 SEQUENCING AND SCHEDULING

- A. Perform testing in the following sequence:
 - 1. Perform routine tests as the equipment is installed including:
 - a. Insulation resistance tests.
 - b. Continuity tests.
 - c. Rotational tests.
 - 2. Adjusting and preliminary calibration.
 - 3. Acceptance tests.

4. Demonstration.
5. Commissioning and plant start-up.
- B. Perform inspection and electrical tests after equipment listed herein has been installed.
- C. Perform tests with apparatus de-energized whenever feasible.
- D. Inspection and electrical tests on energized equipment shall be:
 1. Scheduled with Engineer prior to de-energization.
 2. Minimized to avoid extended period of interruption to the operating plant equipment.
- E. Notify Engineer at least 24 hours prior to performing tests on energized electrical equipment.
- F. Manufacturer's Services: The services of qualified manufacturer's representatives have been specified for testing under certain specification sections. Coordinate and employ those services as required to provide complete testing in accordance with this section and the manufacturer's recommendations.

1.9 WARRANTY

- A. As specified in Section 26 05 00 – General Requirements for Electrical Work.

1.10 COMMISSIONING

- A. Commissioning and plant start-up, as described in the Specifications, shall not begin until acceptance testing is complete, and operation has been demonstrated to the satisfaction of the Engineer.
- B. Commissioning shall only be attempted as a function of normal plant operation in which plant process flows and levels are routine and equipment operates automatically in response to flow and level parameters or computer command, as applicable:
 1. Simulation of process parameters will be considered only upon receipt of a written request by the Contractor.
- C. Record all motor currents during normal operation.
- D. Record the indications of all power meters every half-hour during commissioning.

PART 2 - PRODUCTS

2.1 SOURCE QUALITY CONTROL

- A. General:
 1. Test instrument calibration:

- a. Utilize a testing laboratory with a calibration program which maintains all applicable test instrumentation within rated accuracy and equal to or greater than requirements established by NETA ATS.
- b. Test instrument calibration shall be in accordance with NETA ATS.
- c. The accuracy shall be traceable to the NIST in an unbroken chain.
- d. Calibrate instruments in accordance with the following frequency schedule:
 - 1) Field instruments: 6 months maximum.
 - 2) Laboratory instruments: 12 months maximum.
 - 3) Leased specialty equipment where the accuracy is guaranteed by the lessor (such as Doble): 12 months maximum.
- e. Dated calibration labels shall be visible on all test equipment.
- f. Maintain an up-to-date instrument calibration record for each test instrument:
 - 1) The records shall show the date and results of each calibration or test.
- g. Maintain an up-to-date instrument calibration instruction and procedure for each test instrument.

PART 3 - EXECUTION

3.1 GENERAL

- A. Perform inspection and testing in accordance with NETA ATS, industry standards, and manufacturer's recommendations.
- B. Tests and inspections shall establish:
 1. Electrical equipment is operational within industry and manufacturer's tolerances and standards.
 2. Installation operates properly.
 3. Equipment is suitable for energization.
 4. Installation conforms to requirements of Contract Documents and NFPA 70, NFPA 70E, NFPA 101, and IEEE C2.

- C. Set, test, and calibrate protective relays, circuit breakers, fuses, power monitoring meters and other applicable devices in accordance with values established by short circuit, coordination, and harmonics studies as specified in Section 26 05 73 – Electrical Systems Analysis.
- D. Adjust mechanisms and moving parts of equipment for free mechanical movement.
- E. Adjust and set electromechanical electronic relays and sensors to correspond to operating conditions, or as recommended by manufacturer.
- F. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench/screw driver to manufacturer’s recommendations, or as otherwise specified in NETA ATS.
- G. Provide proper lubrication of applicable moving parts.
- H. Inform Engineer of working clearances not in accordance with NFPA 70.
- I. Investigate and repair or replace:
 - 1. Electrical items that fail tests.
 - 2. Active components not operating in accordance with manufacturer’s instructions.
 - 3. Damaged electrical equipment.
- J. Electrical Enclosures:
 - 1. Remove foreign material and moisture from enclosure interior.
 - 2. Vacuum and wipe clean enclosure interior.
 - 3. Remove corrosion found on metal surfaces.
 - 4. Repair or replace, as determined by Engineer, door and panel sections having dented surfaces.
 - 5. Repair or replace, as determined by Engineer poor fitting doors and panel sections.
 - 6. Repair or replace improperly operating latching, locking, or interlocking devices.
 - 7. Replace missing or damaged hardware.
 - 8. Finish:
 - a. Provide matching paint and touch up scratches and mars.
 - b. If required because of extensive damage, as determined by Engineer, refinish entire assembly.
- K. Replace fuses and circuit breakers that do not conform to size and type required by the Contract Documents or approved Submittals.

3.2 PREPARATION

- A. Do not begin testing until the following conditions have been met:
1. All instruments required are available and in proper operating condition.
 2. All required dispensable materials such as solvents, rags, and brushes are available.
 3. All equipment handling devices such as cranes, vehicles, chain falls and other lifting equipment are available or scheduled.
 4. All instruction books, calibration curves, or other printed material to cover the electrical devices are available.
 5. Data sheets to record all test results are available.

3.3 SYSTEM CHECKOUT AND STARTUP

- A. Voltage Field Test:
1. Check voltage at point of termination of power company supply system to Project when installation is essentially complete and is in operation.
 2. Check voltage amplitude and balance between phases for loaded and unloaded conditions.
 3. Unbalance Corrections:
 - a. Make written request to power company to correct condition if balance (as defined by NEMA) exceeds 1 percent, or if voltage varies throughout the day and from loaded to unloaded condition more than plus or minus 4 percent of nominal.
 - b. Obtain written certification from responsible power company official that voltage variations and unbalance are within their normal standards if corrections are not made.
- B. Equipment Line Current Tests:
1. Check line current in each phase for each piece of equipment.
 2. Make line current check after power company has made final adjustments to supply voltage magnitude or balance.
 3. If phase current for a piece of equipment is above rated nameplate current, prepare Equipment Line Phase Current Report that identifies cause of problem and corrective action taken.

3.4 INSPECTION AND TESTING

- A. Panelboards

1. Visual and Mechanical Inspection: Include the following inspections and related work:
 - a. Inspect for defects and physical damage, labeling, and nameplate compliance with requirements of up-to-date drawings and panelboard schedules.
 - b. Exercise and perform operational tests of mechanical components and other operable devices in accordance with manufacturer's instruction manual.
 - c. Check panelboard mounting, area clearances, and alignment and fit of components.
 - d. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.
 - e. Perform visual and mechanical inspection for overcurrent protective devices.
 2. Electrical Tests: Include the following items performed in accordance with manufacturer's instruction:
 - a. Ground continuity test ground bus to system ground.
- B. Dry type transformers:
1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with that indicated on the Drawings and specified in the Specifications.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, and grounding.
 - d. Inspect winding connections.
 - e. Verify that resilient mounts are free and that any shipping brackets have been removed.
 - f. Inspect equipment for cleanliness.
 - g. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low resistance ohmmeter.

- 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:

Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - 3) Thermographic survey.
 - h. Verify tap-changer is set at correct ratio for rated output voltage under normal operating conditions.
 - i. Verify proper secondary voltage phase-to-phase and phase-to-ground after energization and prior to loading.
2. Electrical tests:
- a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground:
 - 1) Apply voltage in accordance with manufacturer's published data.

Refer to NETA ATS tables in the absence of manufacturer's published data.
 - 2) Test Duration: 10 minutes with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
 - 3) Results temperature corrected in accordance with NETA ATS, Table 100.14.
 - 4) Temperature corrected insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
 - c. Calculate dielectric absorption ration or polarization index.
 - d. Perform turns ratio tests at all tap positions.
 - e. Verify correct secondary voltage, phase-to-phase and phase-to-neutral after energization and before loading.
3. Test values:
- a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

- b. Bolt-torque levels shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - c. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
 - d. Tap connections are left as found unless otherwise specified.
 - e. Minimum insulation resistance values of transformer insulation shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - 2) Investigate insulation values less than the allowable minimum.
 - f. The dielectric absorption ratio or polarization index shall not be less than 1.0.
 - g. Turns-ratio results should not deviate more than 1/2 percent from either the adjacent coils or calculated ratio.
 - h. Phase-to-phase and phase-to-neutral secondary voltages shall be in agreement with nameplate data.
- C. Cables, 600 volts and less:
- 1. Visual and mechanical inspection:
 - a. Compare cable data with that indicated on the Drawings and specified in the Specifications.
 - b. Inspect exposed sections of cables for physical damage, correct connection as indicated on the Drawings, and for cable bend conformance with manufacturer's minimum allowable bending radius.
 - c. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:

Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - 3) Thermographic survey.

- d. Inspect compression-applied connectors for correct cable match and indentation.
 - e. Inspect for correct identification and arrangements.
 - f. Inspect jacket insulation and condition.
2. Electrical tests:
- a. Perform resistance measurements through bolted connections with low-resistance ohmmeter.
 - b. Perform insulation-resistance tests on each conductor with respect to ground and adjacent conductors:
 - 1) Applied voltage shall be:
500 VDC for 300-volt rated cable.
1,000 VDC for 600-volt rated cable.
 - 2) Test duration shall be 1 minute.
 - c. Perform continuity tests to ensure correct cable connection.
 - d. Verify uniform resistance of parallel conductors.
3. Test values:
- a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - c. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
 - d. Insulation resistance values shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - 2) Investigate values of insulation resistance less than the allowable minimum.

- e. Cables shall exhibit continuity.
- f. Investigate deviations in resistance between parallel conductors.

D. 5kV MEDIUM-VOLTAGE CABLES

1. Visual and mechanical inspection:

a. Inspect each individual exposed cable for:

- 1) Physical damage plus jacket and insulation condition.
- 2) Proper connections in accordance with single-line diagram or approved Submittals.
- 3) Proper shield grounding.
- 4) Proper cable support.
- 5) Proper cable termination.
- 6) Cable bends not in conformance with manufacturer's minimum allowable bending radius.
- 7) Proper arc and fireproofing in common cable areas.
- 8) Proper circuit and phase identification.

b. Mechanical connections:

- 1) Proper lug type for conductor material.
- 2) Proper lug installation.
- 3) Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturers.

c. Conductors Terminated Through Window Type CTs: Verify neutrals and grounds are terminated for correct operation of protective devices.

2. Electrical Tests:

a. Insulation Resistance Tests:

- 1) Utilize 2,500-volt megohmmeter.
- 2) Test each cable individually with remaining cables and shields grounded.
- 3) Test each conductor with respect to ground and to adjacent conductors for 1 minute.

- 4) Evaluate ohmic values by comparison with conductors of same length and type.
- 5) Investigate values less than 50 megohms.
- b. Shield Continuity Tests:
 - 1) By ohmmeter method on each section of conductor.
 - 2) Investigate values in excess of 10 ohms per 1,000 feet of conductors.
3. Test Values:
 - a. In accordance with IEEE 400, ICEA S-93-639, NEMA WC 74, ICEA S-94-649, and ICEA S-97-682 for insulated conductors.
 - b. Each conductor section tested with:
 - 1) Splices and terminations in place but disconnected from equipment.
 - 2) Remaining conductors and shields grounded in accordance with IEEE 400.
 - c. Apply maximum test voltage per NETA ATS, Table 100.6, based on method (DC, AC, PD or VLF) used.
 - d. Measure only leakage current associated with conductor.
 - e. Utilize guard ring or field reduction sphere to suppress corona at disconnected terminations.
 - f. Maximum test voltage shall not exceed limits for terminators specified in IEEE 48, IEEE 386, or manufacturer's specifications.
 - g. Apply test voltage in a minimum of five equal increments until maximum acceptable test voltage is reached.
 - 1) Increments not to exceed ac voltage rating of conductor.
 - 2) Record dc leakage current at each step after a constant stabilization time consistent with system charging current.
 - h. Raise conductor to specified maximum test voltage and hold for 15 minutes or as specified by conductor manufacturer. Record leakage current at 30 seconds and 1 minute, and at 1-minute intervals, thereafter.
 - i. Immediately following test, ground conductor for adequate time period to drain insulation stored charge.
 - j. Test results evaluated on a pass/fail basis.

E. SAFETY SWITCHES, 600 VOLTS MAXIMUM

1. Visual and mechanical inspection:
 - a. Proper blade pressure and alignment.
 - b. Proper operation of switch operating handle.
 - c. Adequate mechanical support for each fuse.
 - d. Proper contact-to-contact tightness between fuse clip and fuse.
 - e. Cable connection bolt torque level in accordance with NETA ATS, Table 100.12.
 - f. Proper phase barrier material and installation.
 - g. Verify fuse sizes and types correspond to one-line diagram or approved Submittals.
 - h. Perform mechanical operational test and verify mechanical interlocking system operation and sequencing.

F. MOLDED AND INSULATED CASE CIRCUIT BREAKERS

1. General: Inspection and testing limited to circuit breakers rated 100 amperes and larger and to motor circuit protector breakers rated 100 amperes and larger.
2. Visual and mechanical inspection:
 - a. Proper mounting.
 - b. Proper conductor size.
 - c. Feeder designation according to nameplate and one-line diagram.
 - d. Cracked casings.
 - e. Connection bolt torque level in accordance with NETA ATS, Table 100.12.
 - f. Operate breaker to verify smooth operation.
 - g. Compare frame size and trip setting with circuit breaker schedules or one-line diagram.
 - h. Verify that terminals are suitable for 75 degrees C rated insulated conductors.
3. Electrical tests:
 - a. Insulation Resistance Tests:

- 1) Utilize 1,000-volt dc megohmmeter for 480-volt and 600-volt circuit breakers.
- 2) Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
- 3) Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
- b. Contact Resistance Tests:
 - 1) Contact resistance in microhms across each pole.
- c. Primary current injection test to verify:
 - 1) Long-time minimum pickup and delay.
 - 2) Short-time pickup and delay.
 - 3) Ground fault pickup and delay.
 - 4) Instantaneous pickup by run-up or pulse method.
4. Test Values:
 - a. Insulation resistance: Test values to comply with NETA ATS, Table 100.1.
 - b. Contact resistance: investigate deviation of 50 percent or more from adjacent poles and similar breakers.
 - c. Primary current injection:
 - 1) Trip characteristics of adjustable trip breakers shall be within manufacturer's published time-current characteristic tolerance band, including adjustment factors.
 - 2) Trip times shall be within limits established by NEMA AB 4, Table 5-3. Alternatively, use NETA ATS, Table 100.7.
 - 3) Instantaneous pickup value shall be within values established by NEMA AB 4, Table 5-4. Alternatively, use NETA ATS, Table 100.8.
- G. Low voltage molded case and insulated case circuit breakers:
 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with that indicated on the Drawings and specified in the Specifications.
 - b. Inspect physical and mechanical condition.

- c. Inspect anchorage and alignment.
 - d. Proper operation of racking interlocks.
 - e. Verify the unit is clean.
 - f. Operate circuit breaker to ensure smooth operation.
 - g. Inspect bolted electrical connections for high resistance by one of the following methods:
 - 1) Use of low resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:

Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - 3) Thermographic survey.
 - h. Inspect operating mechanism, contacts, and arc chutes in unsealed units.
 - i. Check operation of closing and tripping functions of trip devices by activating ground fault relays, undervoltage shunt relays, and other auxiliary protective devices.
 - j. Verify primary and secondary contact wipe, gap setting, and other dimensions vital to breaker operation are correct.
 - k. Check charging motor, motor brushes, associated mechanism, and limit switches for proper operation and condition.
 - l. Check operation of electrically operated breakers in accordance with manufacturer's instructions.
 - m. Check for adequate lubrication on contact, moving, and sliding surfaces.
 - n. Perform adjustments for final protective device settings in accordance with the coordination study and manufacturer's instructions.
2. Electrical tests:
- a. Perform resistance measurements through bolted connections with a low resistance ohmmeter.
 - b. Perform insulation resistance tests for 1 minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed and across each open pole:
 - 1) Apply voltage in accordance with manufacturer's published data.

- 2) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - c. Perform a contact/pole-resistance test.
 - d. Determine long-time pickup and delay by primary current injection.
 - e. Determine short-time pickup and delay by primary current injection.
 - f. Determine ground-fault pickup and delay by primary current injection.
 - g. Determine instantaneous pickup value by primary current injection.
 - h. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data.
 - i. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, antipump function and trip unit battery condition:
 - 1) Reset all trip logs and indicators.
 - j. Verify operation of charging mechanism.
3. Test values:
- a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - c. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
 - d. Insulation resistance values shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - 2) Investigate values of insulation resistance less than the allowable minimum.
 - e. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data:

- 1) If manufacturer's data is not available, investigate any values which deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.
- f. Insulation resistance values of control wiring shall not be less than 2 megohms.
- g. Long-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current characteristic tolerance band including adjustment factors:
 - 1) If manufacturer's curves are not available, trip times shall not exceed the value shown in NETA ATS tables.
- h. Short-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
- i. Ground fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
- j. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
- k. Pickup values and trip characteristics shall be within manufacturer's published tolerances.
- l. Minimum pickup voltage of the shunt trip and close coils shall conform to the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
- m. Breaker open, close, trip, trip-free, antipump, and auxiliary features shall function as designed.
- n. The charging mechanism shall operate in accordance with manufacturer's published data.

H. MEDIUM-VOLTAGE VACUUM CIRCUIT BREAKERS

1. Visual and mechanical inspection:
 - a. Check for proper element alignment.
 - b. Check for proper operation of cubicle shutters and racking mechanism.
 - c. Bolt torque level in accordance with NETA ATS, Table 100.12.

- d. Perform mechanical operational tests on breaker and its operating mechanism in accordance with manufacturer's instructions, plus check:
 - 1) Pull rod adjustment.
 - 2) Trip latch clearance.
 - 3) Overtravel stops.
 - 4) Wipe and gap setting.
 - e. Perform breaker travel and velocity analysis in accordance with manufacturer's instructions; values shall be in accordance with manufacturer's acceptable limits.
 - f. Check contact erosion indicators in accordance with manufacturer's instructions.
 - g. With breaker in TEST position:
 - 1) Trip and close breaker with control switch.
 - 2) Trip breaker by manually operating each protective relay.
2. Electrical tests:
- a. Insulation Resistance Tests:
 - 1) Utilize 2,500-volt dc megohmmeter for 5kV circuit breakers.
 - 2) Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
 - 3) Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
 - b. Contact Resistance Tests:
 - 1) Between the line and load stab of closed contact resistance in microhms across each pole.
 - c. Overpotential Tests:
 - 1) Maximum applied ac voltage in accordance with NETA ATS, Table 100.19.
 - 2) Each pole-to-ground with other poles grounded and contacts closed for 1 minute.
 - d. Minimum pickup voltage tests on trip and close coils.
 - e. Control Wiring Tests:
 - 1) Insulation resistance test at 1,000-volt dc on control wiring, except that connected to solid state components.

- f. Vacuum bottle overpotential integrity test across each vacuum bottle with breaker in OPEN position, in accordance with manufacturer's instructions.
 - g. Power Factor Test (Each Phase):
 - 1) With breaker in both OPEN and CLOSED position.
 - h. Power Factor Test (Each Bushing):
 - 1) Utilize conductive straps and hot collar procedures if bushings are not equipped with power factor tap.
 - 2) Power factor and capacitance test results within nameplate rating of bushings.
3. Test values:
- a. Insulation Resistance Tests: Test values to comply with NETA ATS, Table 100.1.
 - b. Contact Resistance Tests: Investigate deviation of 50 percent or more from adjacent poles and similar breakers.
 - c. Overpotential Tests: Test results evaluated on pass/fail basis.
 - d. Control Wiring Tests: Insulation resistance to be 1 megohm minimum.
 - e. Power Factor Test (Each Phase): Compare power factor and arc chute watt loss with adjacent poles or manufacturer's published data.

I. PROTECTIVE RELAYS

- 1. Visual and Mechanical Inspection:
 - a. Visually check each relay for:
 - 1) Tight cover gasket and proper seal.
 - 2) Unbroken cover glass.
 - 3) Condition of spiral spring and contacts.
 - 4) Disc clearance.
 - 5) Condition of case shorting contacts if present.
 - b. Mechanically check each relay for:
 - 1) Freedom of movement.
 - 2) Proper travel and alignment.
 - c. Verify each relay:

- 1) Complies with Contract Documents, approved Submittal, and application.
 - 2) Is set in accordance with recommended settings from coordination study provided by Engineer.
2. Electrical Tests:
- a. Insulation resistance test on each circuit to frame, except for solid state devices.
 - b. Test on nominal recommended setting for:
 - 1) Pickup parameters on each operating element.
 - 2) Timing at three points on time-current curve.
 - 3) Pickup target and seal-in units.
 - 4) Special tests as required to check operation of restraint, directional, and other elements in accordance with manufacturer's instruction manual.
 - c. Current Injection Tests:
 - 1) For entire current circuit in each section.
 - 2) Secondary injection for current flow of 1 ampere.
 - 3) Test current at each device.

J. INSTRUMENT TRANSFORMERS

1. Visual and Mechanical Inspection:
 - a. Visually check current, potential, and control transformers for:
 - 1) Cracked insulation.
 - 2) Broken leads or defective wiring.
 - 3) Proper connections.
 - 4) Adequate clearances between primary and secondary circuit wiring.
 - b. Verify Mechanically:
 - 1) Grounding and shorting connections have good contact.
 - 2) Withdrawal mechanism and grounding operation, when applicable, operate properly.

- c. Verify proper primary and secondary fuse sizes for potential transformers.

K. METERING

1. Visual and Mechanical Inspection:

- a. Verify meter connections in accordance with appropriate diagrams.
- b. Verify meter multipliers.
- c. Verify meter types and scales conform to Contract Documents.
- d. Check calibration of meters at cardinal points.
- e. Check calibration of electrical transducers.

L. Grounding systems:

1. Visual and mechanical inspection:

- a. Inspect ground system for compliance with that indicated on the Drawings, specified in Specifications, and in the National Electrical Code.
- b. Equipment and circuit grounds in switchboards, motor control centers, and panelboards assemblies for proper connection and tightness.
- c. Ground bus connections in switchboards, motor control centers, and panelboards assemblies for proper termination and tightness.
- d. Effective transformer core and equipment grounding.
- e. Accessible connections to grounding electrodes for proper fit and tightness.
- f. Accessible exothermic-weld grounding connections to verify that molds were fully filled and proper bonding was obtained.
- g. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:

Refer to manufacturer's instructions for proper foot-pound levels
or NETA ATS tables.
- h. Inspect anchorage.

2. Electrical tests:

- a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform fall of potential test or alternative test in accordance with IEEE 81, Section 8.2.1.5 for measurement of the main grounding electrode or system. The main ground electrode system resistance to ground to be no greater than 1 ohm.
 - c. Perform point-to-point tests in accordance with IEEE 81, Section 8.2.1.1 to determine the resistance between the main grounding system and all major electrical equipment frames, the system neutral and any derived neutral points. Equipment ground resistance shall not exceed main ground system resistance by 0.25 ohm.
3. Test values:
- a. Grounding system electrical and mechanical connections shall be free of corrosion.
 - b. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - c. Bolt torque levels shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - d. The resistance between the main grounding electrode and ground shall be as specified in Section 26 05 26 – Grounding and Bonding for Electrical Systems. Investigate point-to-point resistance values that exceed 0.5 ohm.

M. AC INDUCTION MOTORS

1. General: Inspection and testing limited to motors rated 5 horsepower and larger.
2. Visual and mechanical inspection:
 - a. Proper electrical and grounding connections.
 - b. Shaft alignment.
 - c. Blockage of ventilating air passageways.
 - d. Operate motor and check for:
 - 1) Excessive mechanical and electrical noise.
 - 2) Overheating.

- 3) Correct rotation.
 - 4) Check vibration detectors, resistance temperature detectors, or motor inherent protectors for functionability and proper operation.
 - 5) Excessive vibration, in excess of values in NETA ATS, Table 100.10.
- e. Check operation of space heaters.
3. Electrical Tests:
- a. Insulation resistance tests:
 - 1) In accordance with IEEE 43 at test voltages established by NETA ATS, Table 100.1 for:
 - 2) Motors above 200 horsepower for 10-minute duration with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
 - 3) Motors 200 horsepower and less for 1-minute duration with resistances tabulated at 30 seconds and 60 seconds.
 - 4) Insulation resistance values equal to, or greater than, ohmic values established by manufacturers.
 - b. Calculate polarization index ratios for motors above 200 horsepower. Investigate index ratios less than 1.5 for Class A insulation and 2.0 for Class B insulation.
 - c. Insulation resistance test on insulated bearings in accordance with manufacturer's instructions.
 - d. Measure running current and voltage and evaluate relative to load conditions and nameplate full-load amperes.
- N. Rotating machinery:
1. Visual and mechanical inspection:
 - a. Compare equipment nameplate information with that indicated on the Drawings and specified in the Specifications.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, and grounding.
 - d. Inspect air baffles, filter media, cooling fans, slip rings, brushes, and brush rigging.
 - e. Inspect bolted electrical connections for high resistance using one of the following methods:

- 1) Use of low resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:

Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.

Thermographic survey.
 - f. Perform special tests such as gap spacing and machine alignment if applicable.
 - g. Verify correct application of appropriate lubrication and lubrication systems.
 - h. Verify that resistance temperature detector (RTD) circuits conform to that indicated on the Drawings.
2. Electrical tests:
- a. Perform resistance measurements through bolted connections with a low resistance ohmmeter.
 - b. Perform insulation resistance test in accordance with IEEE 43:
 - 1) On motors 200 horsepower and smaller, test duration shall be 1 minute. Calculate dielectric absorption ratio.
 - 2) On motors larger than 200 horsepower, test duration shall be 10 minutes. Calculate polarization index.
 - c. Perform dc dielectric withstand voltage tests on machines rated at 2,300 volts and greater in accordance with IEEE 95.
 - d. Perform phase-to-phase stator resistance test on machines rated at 2,300 volts and greater.
 - e. Perform insulation resistance test on insulated bearings in accordance with manufacturer's published data.
 - f. Test surge protection devices as specified in this Section.
 - g. Test motor starter as specified in this Section.
 - h. Perform resistance tests on resistance temperature detector (RTD) circuits.
 - i. Verify operation of motor space heater.
 - j. Perform a rotation test to ensure correct shaft rotation.

- k. Measure running current and evaluate relative to load conditions and nameplate full-load amperes.
3. Test values:
- a. Inspection:
 - 1) Air baffles shall be clean and installed in accordance with the manufacturer's published data.
 - 2) Filter media shall be clean and installed in accordance with the manufacturer's published data.
 - 3) Cooling fans shall operate.
 - 4) Slip ring alignment shall be within manufacturer's published tolerances.
 - 5) Brush alignment shall be within manufacturer's published tolerances.
 - 6) Brush rigging shall be within manufacturer's published tolerances.
 - b. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - c. Bolt-torque levels shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - d. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
 - e. Air-gap spacing and machine alignment shall be in accordance with manufacturer's published data.
 - f. The dielectric absorption ratio or polarization index shall not be less than 1.0. The recommended minimum insulation ($IR_{1 \text{ min}}$) test results in megohms shall be corrected to 40 degrees Celsius and read as follows:
 - 1) $IR_{1 \text{ min}}$ equals 100 megohms for dc armature and ac windings with form-wound coils above 1 kilovolt.
 - 2) $IR_{1 \text{ min}}$ equals 5 megohms for machines and random-wound stator coils and form-wound coils rated below 1 kilovolt.

Dielectric withstand voltage and surge comparison tests shall not be performed on machines having lower values than those indicated above.

- g. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.
 - h. Investigate phase-to-phase stator resistance values that deviate by more than 10 percent.
 - i. Power factor or dissipation factor values shall be compared to manufacturer's published data:
 - 1) In the absence of manufacturer's published data compare values of similar machines.
 - j. Tip-up values shall indicate no significant increase in power factor.
 - k. If no evidence of distress, insulation failure or waveform nesting is observed by the end of the total time of voltage application during the surge comparison test, the test specimen is considered to have passed the test.
 - l. Bearing insulation resistance measurements shall be within manufacturer's published tolerances:
 - 1) In the absence of manufacturer's published data compare values of similar machines.
 - m. Test results of surge protection devices shall be as specified in this Section.
 - n. Test results of motor starter equipment shall be as specified in this Section.
 - o. RTD circuits shall conform to the design intent and machine protection device manufacturer's published data.
 - p. Heaters shall be operational.
 - q. Vibration amplitudes shall not exceed values in NETA ATS tables:
 - 1) If values exceed those in the NETA ATS tables, perform a complete vibration analysis.
 - r. Machine rotation should match required rotation of connected load.
 - s. Running phase-to-phase voltages should be within 1.0 percent. Running currents shall be balanced and proportional to load condition and nameplate data.
- O. Motor starters, low voltage:

1. Visual and mechanical inspection:
 - a. Compare equipment nameplate information with that indicated on the Drawings and specified in the Specifications.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, and grounding.
 - d. Verify the unit is clean.
 - e. Inspect contactors:
 - 1) Verify mechanical operation.
 - 2) Verify contact gap, wipe, alignment, and pressure are in accordance with manufacturer's published data.
 - f. Motor-running protection:
 - 1) Verify overload element rating is correct for its application.
 - 2) If motor running protection is provided by fuses, verify correct fuse rating.
 - g. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:

Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - 3) Thermographic survey.
 - h. Lubrication requirements:
 - 1) Verify appropriate lubrication on moving current-carrying parts.
 - 2) Verify appropriate lubrication on moving and sliding surfaces.
2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low resistance ohmmeter.
 - b. Perform insulation resistance tests for 1 minute on each pole, phase-to-phase and phase to ground with the starter closed, and across each open pole for 1 minute:

- 1) Test voltage shall be in accordance with manufacturer's published data.
 - 2) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - c. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 VDC for 300-volt rated cable and 1,000 VDC for 600-volt rated cable. Apply the test voltage for 1 minute:
 - 1) For solid state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
 - d. Test motor protection devices in accordance with manufacturer's published data.
 - e. Test circuit breakers as specified in this Section.
 - f. Perform operational tests by initiating control devices.
3. Test values:
- a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - c. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
 - d. Insulation resistance values shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - 2) Investigate values of insulation resistance less than the allowable minimum.
 - e. Insulation resistance values of control wiring shall not be less than 2 megohms.
 - f. Motor protection parameters shall be in accordance with manufacturer's published data.

- g. Circuit breaker test results shall as specified in this Section.
- h. Control devices shall perform in accordance with system design requirements.

P. MEDIUM-VOLTAGE MOTOR CONTROL CENTERS

1. Visual and Mechanical Inspection:

- a. Insulator damage and contaminated surfaces.
- b. Proper barrier and shutter installation and operation.
- c. Proper operation of indicating devices.
- d. Proper overload protection.
- e. Blockage of air-cooling passages.
- f. Proper operation of drawout elements.
- g. Integrity and contamination of bus insulation system.
- h. Check door and device interlocking system by:
 - 1) Closure attempt of device when door is in OFF or OPEN position.
 - 2) Opening attempt of door when device is in ON or CLOSED position.
- i. Check key interlocking systems for:
 - 1) Key captivity when device is in ON or CLOSED position.
 - 2) Key removal when device is in OFF or OPEN position.
 - 3) Closure attempt of device when key has been removed.
 - 4) Correct number of keys in relationship to number of lock cylinders.
 - 5) Existence of other keys capable at operating lock cylinders; destroy duplicate sets of keys.
- j. Check nameplates for proper identification of each:
 - 1) Equipment title and tag number with latest one-line diagram.
 - 2) All devices.
- k. Verify fuse sizes and types conform to Contract Documents or approved Submittal.

- l. Check bus connections for high resistance by calibrated torque wrench applied to bolted joints:
 - 1) Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
 - m. Check operation and sequencing of electrical and mechanical interlock systems by:
 - 1) Closure attempt for locked open devices.
 - 2) Opening attempt for locked closed devices.
 - 3) Key exchange to operate devices in OFF-NORMAL positions.
 - n. Verify performance of each control device and feature furnished as part of motor control center.
 - o. Control Wiring:
 - 1) Compare wiring to local and remote control, and protective devices with elementary diagrams.
 - 2) Check for proper conductor lacing and bundling.
 - 3) Check for proper conductor identification.
 - 4) Check for proper conductor lugs and connections.
 - p. Exercise active components.
 - q. Inspect magnetic contactors for:
 - 1) Correct mechanical operations.
 - 2) Correct contact gap, wipe, alignment, and pressure.
 - 3) Correct torque of connections.
 - r. Perform phasing check on double-ended motor control centers to ensure proper bus phasing from each source.
2. Electrical Tests:
 - a. Insulation Resistance Tests:
 - 1) Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.2.
 - 2) Bus section phase-to-phase and phase-to-ground for 1 minute on each phase.

- 3) Contactor phase-to-ground and across open contacts for 1 minute on each phase.
 - 4) Starter section phase-to-phase and phase-to-ground on each phase with starter contacts closed and protective devices open.
 - b. Overpotential Tests:
 - 1) Maximum applied ac voltage in accordance with NETA ATS, Table 100.9.
 - 2) Phase-to-phase and phase-to-ground for 1 minute for each phase of each bus section.
 - c. Bottle integrity test for vacuum contactors in accordance with manufacturer's procedure.
 - d. Test by Primary Current Injection:
 - 1) Overload units at sensors using 300 percent of motor full-load current: Overload trip times to be in accordance with manufacturer's published data.
 - 2) Check voltage levels at each point on terminal boards and each device terminal.
 - e. Control Wiring Tests:
 - 1) Apply secondary voltage on control power and potential circuits.
 - 2) Check voltage levels at each point on terminal boards and at each device terminal.
 - 3) Insulation resistance test at 1,000-volt dc on control wiring, except that connected to solid state components
 - f. Test indicating and monitoring devices for proper operation.
 - g. Perform setup and testing of solid state relays and multifunction protective devices in accordance with manufacturer's instructions.
 - h. Measure Contact and Power Fuse Resistance:
 - 1) Contact resistance shall not exceed manufacturer's recommended values.
3. Test values:
- a. Insulation Resistance Tests: Test values to comply with NETA ATS, Table 100.1.
 - b. Overpotential Tests: Test results evaluated on pass/fail basis.

- c. Control Wiring Tests: Insulation resistance to be 1 megohm minimum.
- d. Contact and Power Fuse Resistance: Resistance of power fuse not to deviate more than 15 percent between identical fuses.

Q. LOW-VOLTAGE MOTOR CONTROL CENTERS

- 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with that indicated on the Drawings and specified in the Specifications.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, grounding and required clearances.
 - d. Inspect equipment for cleanliness.
 - e. Verify that circuit breaker/fuse sizes and types correspond to the approved submittals and coordination study.
 - f. Verify that current and voltage transformer ratios correspond to that indicated on the Drawings.
 - 1) Check bus connections for high resistance by calibrated torque wrench applied to bolted joints: Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
 - g. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - 3) Thermographic survey.
 - h. Mechanical and electrical interlocks:
 - 1) Attempt closure on locked-open devices.
 - 2) Attempt to open locked-closed devices.
 - 3) Make/attempt key-exchanges in all positions.
 - i. Lubrication requirements:

- 1) Verify appropriate lubrication on moving current-carrying parts.
- 2) Verify appropriate lubrication on moving and sliding surfaces.
- j. Inspect insulators for evidence of physical damage or contaminated surfaces.
- k. Verify correct barrier and shutter installation and operation.
- l. Exercise all active components.
- m. Inspect all indicating and monitoring devices for correct operation.
- n. Proper overload protection for each motor.
- o. Verify that filters are in place and/or vents are clear.
- p. Proper operation of drawout elements.
- q. Integrity and contamination of bus insulation system.
- r. Check door and device interlocking system by:
 - 1) Closure attempt of device when door is in OPEN position.
 - 2) Opening attempt of door when device is in ON or CLOSED position.
- s. Check key interlocking systems for:
 - 1) Key captivity when device is in ON or CLOSED position.
 - 2) Key removal when device is in OFF or OPEN position.
 - 3) Closure attempt of device when key has been removed.
 - 4) Correct number of keys in relationship to number of lock cylinders.
 - 5) Existence of other keys capable of operating lock cylinders; destroy duplicate sets of keys.
- t. Check nameplates for proper identification of:
 - 1) Equipment title and tag number with latest one-line diagram.
 - 2) All devices.
- u. Verify performance of each control device and feature furnished as part of motor control center.
- v. Control Wiring:

- 1) Compare wiring to local and remote control, and protective devices with elementary diagrams.
 - 2) Check for proper conductor lacing and bundling.
 - 3) Check for proper conductor identification.
 - 4) Check for proper conductor lugs and connections.
- w. Inspect contactors for:
- 1) Correct mechanical operations.
 - 2) Correct contact gap, wipe, alignment, and pressure.
 - 3) Correct torque of connections.
- x. Perform visual and mechanical inspection of instrument transformers as specified in this Section.
- y. Inspect control power transformers:
- 1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
 - 2) Verify that primary and secondary fuse/circuit breaker ratings match the submittal drawings.
- z. Perform visual and mechanical inspection of circuit breakers as specified in this Section.
- aa. Perform visual and mechanical inspection of starters as specified in this Section.
- bb. Perform visual and mechanical inspection of dry-type transformers as specified in this Section.
- cc. Perform visual and mechanical inspection of variable frequency drives as specified in this Section.
2. Electrical tests:
- a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter if applicable.
 - b. Perform insulation-resistance tests on each bus, contactor, and starter section, phase-to-phase and phase-to-ground for 1 minute:
 - 1) Perform test in accordance with NETA ATS tables.

- c. Perform an dielectric withstand test on each bus section, each phase to ground with phases not under test grounded, in accordance with manufacturer's published data or NETA ATS tables. Apply the test voltage for 1 minute.
- d. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 VDC for 300-volt rated cable and 1,000 VDC for 600-volt rated cable. Apply the test voltage for 1 minute:
 - 1) For solid state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
- e. Perform ground-resistance tests:
 - 1) Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral and derived neutral points.
- f. Determine the accuracy of all meters.
- g. Control power transformers:
 - 1) Perform insulation resistance tests, winding-to-winding and winding-to-ground:

Test voltages shall be in accordance with NETA ATS tables or as specified by the manufacturer.
 - 2) Perform secondary wiring integrity test:

Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source:

 - (1) Verify correct potential at all devices.
 - 3) Verify correct secondary voltage by energizing primary winding with system voltage:

Measure secondary voltage with the secondary wiring disconnected.
- h. Verify operation of space heaters.
- i. Perform electrical tests of circuit breakers as specified in this Section.
- j. Perform electrical tests of starters as specified in this Section.
- k. Perform electrical tests of dry-type transformers as specified in this Section.
- l. Perform electrical tests of variable frequency drives as specified in this Section.

3. Test values:
 - a. Compare bus connection resistances to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - c. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
 - d. Compare bus connection resistances to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 2) Insulation-resistance values for bus and control power transformers shall be in accordance with manufacturer's published data:

Refer to NETA ATS tables in the absence of manufacturer's published data.

Investigate insulation values less than the allowable minimum.

Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.
 - e. Bus insulation shall withstand the overpotential test voltage applied.
 - f. Insulation-resistance values for control wiring shall not be less than 2.0 megohms.
 - g. Instrument transformer test values shall be as specified in this Section.
 - h. Investigate grounding system resistance values that exceed 0.5 ohm.
 - i. Meter accuracy shall be in accordance with manufacturer's published data.
 - j. Control power transformers:
 - 1) Insulation resistance values of control power transformers shall be in accordance with manufacturer's published data:

Refer to NETA ATS tables in the absence of manufacturer's published data.

Investigate insulation values less than the allowable minimum.

Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.

- 2) Secondary wiring shall be in accordance with that indicated on the Drawings and specified in the Specifications.
 - 3) Secondary voltage shall be in accordance with that indicated on the Drawings.
- k. Heaters shall be operational.
 - l. Test values for circuit breakers shall be as specified in this Section.
 - m. Test values for starters shall be as specified in this Section.
 - n. Test values for dry-type transformers shall as specified in this Section.
 - o. Test values for variable frequency drives shall be as specified in this Section.

R. ACTIVE HARMONIC CONDITIONERS

1. Visual and mechanical inspection:
 - a. Inspect equipment for signs of damage
 - b. Verify installation per drawings.
 - c. Verify current transformer orientation and wiring to power correction system.
 - d. Proper connection and grounding.
 - e. Verify that fuse types and ratings conform to shop Drawings.
 - f. Verify logic setup corresponds to performance specifications.
 - g. Check wiring and terminal connections for tightness.
2. Electrical tests:
 - a. Electrical and functional tests in accordance with manufacturer's instructions.
 - b. Functional test of all control and indication devices.
3. Test values:
 - a. Performance testing: Test shall document specified control of current and voltage harmonic distortion.

- S. Variable frequency drive systems:
 - 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with that indicated on the Drawings and specified in the Specifications.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, and grounding.
 - d. Verify the unit is clean.
 - e. Ensure vent path openings are free from debris and that heat transfer surfaces are clean.
 - f. Verify correct connections of circuit boards, wiring, disconnects, and ribbon cables.
 - g. Motor running protection:
 - 1) Verify drive overcurrent setpoints are correct for their application.
 - 2) If drive is used to operate multiple motors, verify individual overload element ratings are correct for their application.
 - 3) Apply minimum and maximum speed setpoints. Verify setpoints are within limitations of the load coupled to the motor.
 - h. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - 3) Thermographic survey.
 - i. Verify correct fuse sizing in accordance with manufacturer's published data.
 - j. Perform visual and mechanical inspection of input circuit breaker as specified in this Section.
 - 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with low-resistance ohmmeter.

- b. Test the motor overload relay elements by injecting primary current through the overload circuit and monitoring trip time of the overload element.
 - c. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 VDC for 300-volt rated cable and 1,000 VDC for 600-volt rated cable. Apply the test voltage for 1 minute:
 - 1) For solid state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
 - d. Test for the following parameters in accordance with relay calibration procedures specified in this Section or as recommended by the manufacturer:
 - 1) Input phase loss protection.
 - 2) Input overvoltage protection.
 - 3) Output phase rotation.
 - 4) Overtemperature protection.
 - 5) Direct current overvoltage protection.
 - 6) Overfrequency protection.
 - 7) Drive overload protection.
 - 8) Fault alarm outputs.
 - e. Perform continuity tests on bonding conductors as specified in this Section.
 - f. Perform start-up of drive in accordance with manufacturer's published data. Calibrate drive to the system's minimum and maximum speed control signals.
 - g. Perform operational tests by initiating control devices:
 - 1) Slowly vary drive speed between minimum and maximum. Observe motor and load for unusual noise or vibration.
 - 2) Verify operation of drive from remote start/stop and speed control signals.
 - h. Perform electrical tests of input circuit breaker as specified in this Section.
3. Test values:
- a. Compare bolted connection resistances to values of similar connections:

- 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - c. Results of the thermographic survey shall be in accordance with NETA ATS requirements.
 - d. Overload test trip times at 300 percent of overload element rating shall be in accordance with manufacturer's published time-current curve.
 - e. Test values for input circuit breaker shall be as specified in this Section.
 - f. Insulation-resistance values for control wiring shall not be less than 2.0 megohms.
 - g. Relay calibration results shall be as specified in this Section.
 - h. Continuity of bonding conductors shall be as specified in this Section.
 - i. Control devices shall perform in accordance with system requirements.
 - j. Operational tests shall conform to system design requirements.
- T. Surge arresters, low-voltage:
1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with that indicated on the Drawings and specified in the Specifications.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, grounding, and clearances.
 - d. Verify the arresters are clean.
 - e. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:

Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - f. Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.

- g. Verify that stroke counter is correctly mounted and electrically connected, if applicable.
 - h. Record stroke counter reading.
- 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform an insulation-resistance test on each arrester, phase terminal-to-ground:
 - 1) Apply voltage in accordance with manufacturers published data.
 - 2) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - c. Test grounding connection as specified in this Section.
 - d. Varistor Type Arrestors:
 - 1) Clamping voltage test.
 - 2) Rated RMS voltage test.
 - 3) Rated dc voltage test.
 - 4) Varistor arrester test values in accordance with IEEE C62.33, Section 4.4 and Section 4.9.
- 3. Test values:
 - a. Compare bolted connection resistances to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - c. Insulation resistance values shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - 2) Investigate insulation values less than the allowable minimum.

- d. Resistance between the arrester ground terminal and the ground system shall be less than 0.5 ohm.
- U. Fiber-optic cables:
- 1. Visual and mechanical inspection:
 - a. Compare cable, connector, and splice data with that indicated on the Drawings and specified in the Specifications:
 - b. Inspect cable and connections for physical and mechanical damage.
 - c. Verify that all connectors and splices are correctly installed.
 - 2. Electrical tests:
 - a. Perform cable length measurement, fiber fracture inspection, and construction defect inspection using an optical time domain reflectometer (OTDR):
 - 1) OTDR test performed on fiber cables less than 100 meters shall be performed with the aid of a launch cable.
 - 2) Adjust OTDR pulse width settings to a maximum setting of 1/1000th of the cable length or 10 nanoseconds.
 - b. Perform connector and splice integrity test using an optical time domain reflectometer.
 - c. Perform cable attenuation loss measurement with an optical power loss test set:
 - 1) Perform attenuation tests with an Optical Loss Test Set capable and calibrated to show anomalies of 0.1 dB as a minimum.
 - 2) Test multimode fibers at 850 nanometer and 1,300 nanometer.
 - 3) Test single mode fibers at 1,310 nanometer and 1,550 nanometer.
 - d. Perform connector and splice attenuation loss measurement from both ends of the optical cable with an optical power loss test set:
 - 1) At the conclusion of all outdoor splices at one location, and before they are enclosed and sealed, all splices shall be tested with OTDR at the optimal wavelengths (850 and 1,300 for multimode, 1,310 and 1,550 for single mode), in both directions. The splices shall be tested for integrity as well as attenuation.
 - e. Perform fiber links integrity and attenuation tests using each link shall be an OTDR and an Optical Loss Test Set:

- 1) OTDR traces shall be from both directions on each fiber at the 2 optimal wavelengths, 850 nanometer and 1,300 nanometer for multimode fibers.
 - 2) Optical loss testing shall be done with handheld test sets in 1 direction at the 2 optimal wavelengths for the appropriate fiber type. Test equipment shall equal or exceed the accuracy and resolution of Agilent/HP 8147 high performance OTDR.
3. Test values:
- a. Cable and connections shall not have been subjected to physical or mechanical damage.
 - b. Connectors and splices shall be installed in accordance with industry standards.
 - c. The optical time domain reflectometer signal should be analyzed for excessive connection, splice, or cable backscatter by viewing the reflected power/distance graph.
 - d. Attenuation loss measurement shall be expressed in dB/km. Losses shall be within the manufacturer's recommendations when no local site specifications are available.
 - e. Individual fusion splice losses shall not exceed 0.1 dB. Measurement results shall be recorded, validated by trace, and filed with the records of the respective cable runs.
- V. LAN cable testing:
1. Visual and mechanical inspections:
 - a. Compare cable type and connections with that indicated on the Drawings and specified in the Specifications.
 - b. Inspect cable and connectors for physical and mechanical damage.
 - c. Verify that all connectors are correctly installed.
 2. Pre-testing:
 - a. Test individual cables before installation:
 - 1) Before physical placement of the cable, test each cable while on the spool with a LAN certification test device.
 - 2) Before the cable is installed, verify that the cable conforms to the manufacturer's attenuation specification and that no damage has been done to the cable during shipping or handling.

- 3) The test shall be fully documented and the results submitted to the Engineer, including a hard copy of all traces, before placement of the cable.
 - 4) The Engineer shall be notified if a cable fails to meet specification and the cable shall not be installed unless otherwise directed by the Engineer.
3. Electrical tests:
- a. Perform cable end-to-end testing on all installed cables after installation of connectors from both ends of the cable.
 - b. Test shall include cable system performance tests and confirm the absence of wiring errors.
4. Test results:
- a. Cables shall meet or exceed TIA standards for a Category 5e or Category 6 installation, as applicable.
5. Test equipment:
- a. LAN certification equipment used for the testing shall be capable of testing Category 6 cable installation to TIA proposed Level III accuracy. Tests performed shall include:
 - 1) Near end cross talk.
 - 2) Attenuation.
 - 3) Equal level far end cross talk.
 - 4) Return loss.
 - 5) Ambient noise.
 - 6) Effective cable length.
 - 7) Propagation delay.
 - 8) Continuity/loop resistance.
 - b. LAN certification test equipment shall be able to store and produce plots of the test results.
 - c. Acceptable manufacturers: The following or equal:
 - 1) Agilent Technologies, WireScope 350.

W. Capacitors and reactors, capacitors:

1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with that indicated on the Drawings and specified in the Specifications.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, grounding, and clearances.
 - d. Verify the unit is clean.
 - e. Verify that capacitors are electrically connected in their specified configuration.
 - f. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method:

Refer to manufacturer's instructions for proper foot-pound levels
NETA ATS tables.
 - 3) Perform thermographic survey.
2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable.
 - b. Perform insulation-resistance tests from phase terminal(s) to case for one minute.
 - 1) Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, refer to NETA ATS tables.
 - c. Measure the capacitance of all terminal combinations.
 - d. Measure resistance of the internal discharge resistors.
3. Test values:
 - a. Test values - visual and mechanical:
 - 1) Compare bolted connection resistance values to values of similar connections.

Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

- 2) Bolt-torque levels shall be in accordance with manufacturer's published data:

Refer to NETA ATS tables in the absence of manufacturer's data.

- 3) Results of the thermographic survey shall be in accordance with NETA ATS requirements.

b. Test values - electrical:

- 1) Compare bolted connection resistance values to values of similar connections:

Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

- 2) Insulation-resistance values shall be in accordance with manufacturer's published data:

Refer to NETA ATS tables in the absence of manufacturer's published data.

Values of insulation resistance less than NETA ATS tables or manufacturer's recommendations should be investigated.

- 3) Investigate capacitance values differing from manufacturer's published data.

- 4) Investigate discharge resistor values differing from manufacturer's published data. In accordance with NFPA 70 NEC, Article 460, residual voltage of a capacitor shall be reduced to 50 volts in the following time intervals after being disconnected from the source of supply:

Rated Voltage	Discharge Time
Less than or equal to 600 volts	1 minute
Greater than 600 volts	5 minutes

3.5 ADJUSTING

- A. Adjust limit switches and level switches to their operating points before testing.
- B. Set pressure switches, flow switches, and timing relays to anticipated values before testing:
 1. Final settings shall be as dictated by operating results during testing.

3.6 CLEANING

- A. As specified in Section 26 05 00 – General Requirements for Electrical Work.

- B. After the acceptance tests have been completed, dispose of all testing expendables, vacuum all cabinets, and sweep clean all surrounding areas.
- C. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.

3.7 DEMONSTRATION AND TRAINING

- A. As specified in Section 26 05 00 – General Requirements for Electrical Work.
- B. Subsystem demonstration:
 - 1. Subsystem, as used in this Section, means individual and groups of pumps, conveyor systems, chemical feeders, air conditioning units, ventilation fans, air compressors, blowers, lighting control systems and other electrically operated or controlled equipment.
 - 2. Before demonstrating any subsystem:
 - a. Demonstrate proper operation of all alarm and status contacts.
 - b. Adjust and calibrate all process and control devices as accurately as possible.
 - 3. Operate each subsystem in its manual mode:
 - a. Demonstrate compliance with all Contract requirements.
 - 4. After each subsystem has operated successfully in its manual mode, perform automatic and remote operation demonstrations:
 - a. Verify that all features are fully operational and meet all Contract requirements.
 - b. Demonstrate all operating modes and sequences, including proper start and stop sequence of pumps, proper operation of valves and proper speed control.

3.8 PROTECTION

- A. As specified in Section 26 05 00 – General Requirements for Electrical Work.

3.9 SCHEDULES

- A. At least 30 days before commencement of the acceptance tests, submit the manufacturer's complete field testing procedures to the Engineer and to the testing laboratory, complete with expected test results and tolerances for all equipment to be tested.

END OF SECTION 26 08 00

SECTION 26 09 13 - INSTRUMENT TRANSFORMERS AND METERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Scope: This section specifies instrument transformers, and meters for motor control centers, switchboards, and other electrical distribution equipment assemblies.

1.2 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
 - 1. American National Standards Institute (ANSI)
 - a. ANSI C37.20, Switchgear Assemblies Including Metal-Enclosed Bus
 - b. ANSI C39.1, Requirements for Electrical Analog Indicating Instruments
 - c. ANSI C57.13, Requirements for Instrument Transformers

1.3 SUBMITTALS

- A. Action Submittal Items for this Section:
 - 1. A copy of this Section, addendum updates included, with each paragraph check-marked to indicate compliance or marked to indicate requested deviations from Section requirements.
 - 2. Catalog cuts of equipment, devices, and materials installed under this section. Catalog information shall include technical specifications and application information, including electrical ratings, dimensions, weight, etc. Catalog cuts shall be edited to show only the items, model numbers, and information which apply.
 - 3. Operation and maintenance items as specified in Project Specifications.
 - 4. Manufacturer's product data with features and dimensions of devices.
 - 5. Burden, accuracy class, and ratio data for instrument transformers.

PART 2 - PRODUCTS

2.1 INSTRUMENT TRANSFORMERS

- A. GENERAL: Instrument transformers shall be molded dry-type in accordance with ANSI C57.13. Transformer volt-ampere rating shall be suitable for carrying the specified load without overheating or exceeding the permissible accuracy for the transformer.

- B. CURRENT TRANSFORMERS: Current transformers shall be furnished with the specified ratios. The accuracies shall conform to ANSI C37.20. Add shorting terminal blocks for all current transformers.

2.2 POWER MONITOR AND DISPLAY (PMD)

- A. Power monitor and display unit shall be provided where shown on the one-line diagram. The unit shall monitor all three phases and shall display volts (phase to phase and phase to neutral), amperes, power factor, and hertz. The PMD shall be supplied with native Ethernet IP communications port (no exceptions) for internal networking via Ethernet switch within switchgear and motor control centers, and to the plant control network.
- B. Service Entrance Switchgear and Motor Control Centers: Allen Bradley PowerMonitor 5000 model M6 with integral display module, or equivalent.
- C. Main Lug Only Motor Control Centers: Allen Bradley PowerMonitor 500, or equivalent.
- D. Provide blown fuse indicators on all fuses.
- E. Provide current transformers with a minimum of 1% accuracy at 10% of range, and all mounting hardware, including but not limited to, shorting terminal blocks for a complete installation.
- F. Mount the power monitor in the unit door between 54" and 66" above the floor when installed on the house keeping pad.
- G. Power monitors shall be powered at 120V via UPS within the switchgear or motor control center. Provide circuit with required overcurrent protection and disconnecting means.

2.3 NAMEPLATES

- A. Refer to Section 26 05 00 - General Requirements for Electrical Work.

PART 3 - EXECUTION

3.1 GENERAL

- A. Accessories and devices shall be installed per the electrical distribution equipment manufacturer's instructions.
- B. Verify PMD's operate in accordance the control strategy specified in Project Specifications.

END OF SECTION 26 09 13

SECTION 26 12 19 – PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. The Institute of Electrical and Electronics Engineer, Inc. (IEEE):
 - a. 386 - IEEE Standard for Separable Insulated Connector Systems for Power Distribution Systems Rated 2.5 kV through 35 kV.
 - b. C2 - National Electric Safety Code.
 - c. C37.47 - IEEE Standard Specifications for High-Voltage (>1000 V) Distribution Class Current-Limiting Type Fuses and Fuse Disconnecting Switches.
 - d. C57.12.00 - IEEE Standard for General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.
 - e. C57.12.26 - IEEE Standard for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers for Use with Separable Insulated High-Voltage Connectors (34 500 GrdY/19 920 Volts and Below, 2500 kVA and Smaller).
 - f. C57.12.28 - IEEE Standard for Pad-Mounted Equipment - Enclosure Integrity.
 - g. C57.12.36 - IEEE Standard Requirements for Liquid-Immersed Distribution Substation Transformers.
 - h. C57.12.70 - IEEE Standard for Standard Terminal Markings and Connections for Distribution and Power Transformers.
 - i. C57.12.90 – IEEE Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers.
 - j. C62.11 - IEEE Standard for Metal-Oxide Surge Arresters for AC Power Circuits (>1 kV).
 2. International Electrical Testing Association (NETA):
 - a. ATS - Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems.
 3. Nationally Recognized Testing Laboratories (NRTL).
 4. American Society of Civil Engineers (ASCE):

- a. SEI 7 – 10 - Minimum Design Loads for Buildings and Other Structures.
5. Department of Energy (DOE):
 - a. 10 CFR 431, Subpart K – Distribution Transformers.
6. National Fire Protection Association (NFPA): 70
7. International Organization for Standardization (ISO):
 - a. 9001, Quality Management Systems Requirements.
8. American Society for Testing and Materials (ASTM):
 - a. A 167 - Specification for stainless steel and heat-resisting chromium-nickel steel plate, sheet, and strip
 - b. D 117 - Standard Guide for Sampling, Test Methods, and Specifications for Electrical Insulating Oils of Petroleum Origin.
 - c. D 877 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
 - d. D 923 - Standard Practices for Sampling Electrical Insulating Liquids.
 - e. D 971 - Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method.
 - f. D 974 - Standard Test Method for Acid and Base Number by Color-Indicator Titration.
 - g. D 1500 - Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale).
 - h. D 1524 - Standard Test Method for Visual Examination of Used Electrical Insulating Liquids in the Field.
 - i. D 1816 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using VDE Electrodes.
 - j. D 3487 - Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus.
9. Underwriters Laboratories (UL):
 - a. 1562 - Standard for Transformers, Distribution, Dry-Type - Over 600 Volts.
10. National Electrical Manufacturers Association (NEMA):
 - a. TR 1 – Transformers, Regulators, and Reactors.

- b. TP 1, Guide for Determining Energy Efficiency for Distribution Transformers.
- 11. Occupational Safety and Health Administration (OSHA):
 - a. 29 CFR 1910.269 - Electric Power Generation, Transmission, and Distribution.
 - 12. Uniform Building Code (UBC): Section 1630, Lateral Force on Elements of Structures, Non-Structural Components, and Equipment Supported by Structures.

1.2 SUBMITTALS

A. Action Submittals:

- 1. Rated capacities.
- 2. Descriptive information for the transformer and all specified components.
- 3. Dimensional drawings, plans and elevations showing major components and features.
- 4. Nameplate data.
- 5. High voltage switch arrangement (one-line diagram) for each transformer,
- 6. Manufacturer's published time-current curves of the transformer high-voltage fuses, with transformer damage curve, inrush curve, and thru fault current indicated.

B. Informational Submittals:

- 1. Operation and Maintenance Data.
 - a. Operation manual.
 - b. Maintenance manual.
 - c. Emergency manual.
 - d. Manufacturer's written instructions for preventative maintenance.
 - e. Time-current curves of overcurrent protective devices.
 - f. Local Representatives
 - 1) Where to order parts: Name, Address, Telephone.
 - 2) Service Problems:
 - a) Who to call.

b) How to get emergency help.

1.3 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Design, test, and assemble in accordance with applicable standards of IEEE C57.12.00, C57.12.22, C57.12.26, C57.12.70, C57.12.80, C57.12.90, and C57.12.92.

1.4 EXTRA MATERIALS

- A. Furnish, tag, and box for shipment and storage the following spare parts, special tools, and materials.
 - 1. One quart of paint to match color and quality of equipment final shop finish.
 - 2. Two spare fuses for each transformer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

- A. ABB
- B. Square D Co.
- C. General Electric
- D. Eaton
- E. Howard Industries, Inc.

2.2 GENERAL

- A. Transformer Locations: Outdoors.
- B. Winding Connections: The connection of windings and terminal markings shall comply with IEEE C57.12.70.
- C. Efficiency: Comply with 10 CFR 431, Subpart K (DOE 2016).
- D. Insulation: Transformer kVA rating shall be as follows: The average winding temperature rise above a 30 deg C ambient temperature shall not exceed 65 deg C and 80 deg C hottest-spot temperature rise at rated kVA when tested according to IEEE C57.12.90, using combination of connections and taps that give the highest average winding temperature rise.
- E. Tank: Sealed, with welded-on cover.

- F. Enclosure Integrity: Comply with IEEE C57.12.28 for pad-mounted enclosures that contain energized electrical equipment in excess of 600 V that may be exposed to the public.
- G. Mounting: An integral skid mounting frame, suitable to allow skidding or rolling of transformer in any direction, and with provision for anchoring frame to pad.
- H. Insulating Liquids:
 - 1. Mineral Oil: ASTM D 3487, Type II, and tested for compliance with ASTM D 117. Retro fillable with homogeneous biodegradable fluid if the Owner decides to do so in the future.
- I. Sound level shall comply with NEMA TR 1 requirements.
- J. Corrosion Protection:
 - 1. Transformer coating system shall be factory applied, complying with requirements of IEEE C57.12.28, in manufacturer's standard color Munsell 7GY3.29/1.5 green.
- K. Warning Labels and Signs:
 - 1. High-Voltage Warning Label: Provide self-adhesive warning signs on outside of high-voltage compartment door(s). Sign legend shall be "DANGER HIGH VOLTAGE" printed in two lines of nominal 2-inch (50-mm) high letters. The word "DANGER" shall be in white letters on a red background and the words "HIGH VOLTAGE" shall be in black letters on a white background.
 - 2. Arc Flash Warning Label: Provide self-adhesive warning signs on outside of high-voltage compartment door(s), warning of potential electrical arc flash hazards and appropriate personal protective equipment required.
- L. Service Conditions
 - 2. Transformers shall be suitable for operation under service conditions specified as usual service conditions in IEEE C57.12.00.

2.3 THREE PHASE TRANSFORMERS

- A. Capacities and Characteristics:
 - 1. Self-Cooled Rating, Class ONAN. Comply with IEEE C57.12.00 for cooling class.
 - 2. Power Rating (kVA): Size as shown on Drawings.
 - 3. Primary Voltage Ratings: 12,470GrdY/7,200V, three-phase, 60-Hz.
 - 4. Secondary Voltage Ratings: 480GrdY/277V, 60-Hz as shown on Drawings.
 - 5. Taps: Comply with IEEE C57.12.26 requirements.

- a. 480GrdY/277V Units: Full capacity, two 2-1/2 percent below and two 2-1/2 percent above, rated voltage.
 - b. Externally operated no-load tap changer.
 - c. Provisions for locking handle in any position.
6. Transformer BIL (kV): Comply with IEEE C57.12.26 requirements.
- a. Primary: 95-kV BIL.
 - b. Secondary: 30-kV BIL (600V or less).
- B. Windings Material: Copper.
- C. Impedance: Manufacturer's standard.
- D. Wye-wye transformers wound on four-or five legged cores.
- E. Terminal Compartments
1. General: ANSI C57.12.28, enclosed high and low voltage compartments side by side, separated by steel barrier, bolted to transformer tank. Terminal compartment enclosure shall have no exposed screws, bolts, or other fasteners which are externally removable.
 - a. Doors:
 - 1) Individual, full-height, air-filled.
 - 2) Low voltage door with three-point latching mechanism, vault type handle, and single padlocking provision.
 - 3) High voltage door fastenings inaccessible until low voltage door has been opened.
 - 4) Door bolts: Hex-head type.
 - 5) Lift-off, stainless steel hinges and door stops.
 - 6) Removable front sill to facilitate rolling of skidding over conduit stubs.
 - 7) Recessed lock pocket, with steel door release bolt adjacent to secondary compartment door handle.
 2. High Voltage Compartment:
 - a. Dead-front in accordance with ANSI C57.12.26 type construction.
 - b. Protective fuses.

- c. High voltage bushings.
 - d. Transformer grounding pad.
 - e. High voltage switch.
3. Low Voltage Compartment:
- a. Live-front in accordance with ANSI C57.12.26 type construction.
 - b. Low voltage bushings.
 - c. Stainless steel grounding pad.
 - d. Stainless steel equipment nameplate.
 - e. Magnetic liquid level indicator with high and low alarm contacts.
 - f. 1-inch upper filter press and filling plug.
 - g. Drain valve with sampling device.
 - h. Dial type thermometer and alarm contacts.
 - i. Pressure relief valve.
 - j. Pressure relief device, self-resealing with indicator.
 - k. Pressure-vacuum gauge.
 - l. Machine-engraved nameplate, made of anodized aluminum or stainless steel.

F. Bushings

1. High Voltage:
 - a. Dead-front termination:
 - 1) Universal bushing wells and bushing well inserts rated 15 kV in accordance with IEEE 386.
 - 2) Bushings externally clamped and front removable.
 - 3) Rated for 200 amperes continuous.
 - 4) Standoff brackets located to bushings.
 - 5) Terminations arranged for loop feed.
2. Low Voltage (below 600V):

- a. Live front.
 - b. Molded epoxy bushing clamped to tank. 6-hole spade-type terminals for units 2,000 kVA and smaller. 8-hole spade-type terminals for 2,500 kVA units.
 - c. Rated 150 percent of continuous full-load current.
 - d. Internally connected neutral extended to neutral bushing.
- G. High Voltage Switch
1. Provide OFF-ON load break, gang operated, oil-immersed switch.
 2. Hot stick operated handle located in high voltage compartment.
 3. Capable of operating at full-load current.
 4. Switch Configuration: Radial.
- H. High Voltage Protection
1. Bayonet-type, liquid-immersed, expulsion fuses in series with liquid-immersed, partial-range, current-limiting fuses. Bayonet fuse shall sense both high currents and high oil temperature to provide thermal protection to the transformer. Connect current-limiting fuses ahead of radial-feed load-break switch.
 2. Provide oil retention valve and an external drip shield inside the housing to eliminate or minimize oil spills. Valve shall close when fuse holder is removed and an external drip shield is installed.
 3. Provide a conspicuously displayed warning adjacent to bayonet fuse(s), cautioning against removing or inserting fuses unless transformer has been de-energized and tank pressure has been released.
- I. Surge Arresters
1. Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, fully shielded, separable-elbow type, suitable for plugging into the inserts provided in the high-voltage section of the transformer. Connected in each phase of incoming circuit and ahead of any disconnecting device.
- J. Tank Grounding Pads
1. High and Low Voltage Compartments:
 - a. Connected together with bare No. 2/0 stranded copper conductors.
 - b. Wye-wye high and low voltage neutrals internally connected with link and brought out to insulated low voltage bushing externally grounded to tank.

- c. Low voltage neutral connected to externally mounted insulating bushing in low voltage compartment and grounded to tank with removable strap.

K. Tap Changer Warning Sign

1. Red laminated plastic, engraved to white core.
2. Engrave to read DO NOT OPERATE WHEN TRANSFORMER ENERGIZED.
3. Mount above tap changer handle.

2.4 SOURCE QUALITY CONTROL

A. Provide manufacturer's certificate that the transformer design tests comply with IEEE C57.12.90.

1. Perform the following factory-certified routine tests:
 - a. Resistance.
 - b. Turns ratio, polarity, and phase relation.
 - c. Transformer no-load losses and excitation current at 100 percent of ratings.
 - d. Transformer impedance voltage and load loss.
 - e. Operation of all devices.
 - f. Lightning impulse.
 - g. Low frequency.
 - h. Leak.
 - i. Transformer no-load losses and excitation current at 110 percent of ratings.
 - j. Induced potential.
 - k. Resistance measurements of all windings on rated voltage connection and at tap extreme connections.
 - l. Ratios on rated voltage connection and at tap extreme connections.
 - m. Polarity and phase relation on rated voltage connection.
 - n. No-load loss at rated voltage on rated voltage connection.
 - o. Exciting current at rated voltage on rated voltage connection.
 - p. Impedance.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install transformers in conformance with product shop drawings and installation instructions.
- B. Provide foundation pads as shown. Verify exact dimensions and configuration of all pads, including penetrations, with product shop drawings. Secure to mounting pads with anchor bolts.
- C. Anchor Bolts:
 - 1. Where required, provide anchor bolts, fasteners, washers, and templates needed for installation of equipment.
 - 2. Size and locate anchor bolts in accordance with product shop drawings and installation instructions.
- D. Equipment shall be properly aligned with pad and adjacent building walls, plumb and level, with no stresses on connecting conduit.
- E. Verify proper phasing before energizing equipment.
- F. Ground neutrals and enclosures in accordance with applicable codes.
- G. Adjust voltage taps to obtain rated output voltage under normal operating load conditions.
- H. Verify operability and safety of electrical system needed to operate equipment. Check electrical system for continuity, phasing, grounding, and proper functions.

3.2 MANUFACTURER'S SERVICES

- A. Furnish manufacturer's representative for the following at the project site for 0.5 person-days (travel time excluded) for installation inspection and transformer electrical tests. Complete operation and maintenance manuals shall be available at least 30 days prior to the inspection date.

END OF SECTION 26 12 19

SECTION 26 21 00 - SERVICE ENTRANCE

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Coordinate [new or existing] incoming power service with Idaho Power. Idaho Power contact is Tyler Morgensen, (208) 388-5395.
- B. Coordinate [installation of new, or modification of existing] power feed to the facility as indicated on the plans.
- C. Contractor to coordinate with Idaho Power Company to provide counter clockwise phase rotation.
- D. Verify exact location of service feeds and transformers with Idaho Power. Power service shall be maintained. Any and all power shut downs shall be scheduled and coordinated with the owner and related trades.

PART 2 - PRODUCTS NOT USED

PART 3 - EXECUTION

3.1 GENERAL

- A. Install, modify or demolish service-entrance equipment as indicated on the plans. New equipment to be installed, in accordance with equipment manufacturer's written instructions, and with recognized industry practices, to ensure that service-entrance equipment fulfills requirements. Comply with applicable installation requirements of NEC, UL, ANSI, IEEE, and NEMA standards.
- B. Tighten electrical connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque-tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standards 486A and B, and the NEC.

END OF SECTION 26 21 00

SECTION 26 22 00 – LOW VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 SUBMITTALS

- A. Product Data Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.
- B. Shop Drawings: Wiring and connection diagrams.
- C. Source quality-control test reports.
- D. Output Settings Reports: Record of tap adjustments specified in Part 3.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with IEEE C 57.12.91.
- C. Energy-Efficient Transformers Rated 15 kVA and Larger: Certified as meeting NEMA TP 1, Class 1 efficiency levels when tested according to NEMA TP 2.

1.5 DELIVERY, STORAGE, AND HANDLING

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

1.6 COORDINATION

- A. Coordinate installation of wall-mounting and structure-hanging supports.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Siemens.
 - 2. GE Electrical Distribution & Control.
 - 3. Square D/Group Schneider NA.
 - 4. Eaton Electrical
 - 5. Approved equal

2.2 MATERIALS

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

2.4 DISTRIBUTION TRANSFORMERS

- A. Comply with NEMA ST 20, and list and label as complying with UL 1561.
- B. Cores: One leg per phase.
- C. Enclosure: Ventilated, NEMA 250, Type 2.
- D. Indoor Transformer Enclosure Finish: Comply with NEMA 250 for "Indoor Corrosion Protection."
 - 1. Finish Color: Gray.
- E. Outdoor Transformer Enclosure Finish: Comply with NEMA 250 for "Outdoor Corrosion Protection."
 - 1. Finish Color: Gray.
- F. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 150 deg C rise above 40 deg C ambient temperature.

- G. Taps for Transformers Smaller Than 3 kVA: None.
- H. Taps for Transformers 7.5 to 24 kVA: Two 5 percent taps below rated voltage.
- I. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.
- J. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.
 - 1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
 - 2. Include special terminal for grounding the shield.
 - 3. Shield Effectiveness:
 - a. Capacitance between Primary and Secondary Windings: Not to exceed 33 picofarads over a frequency range of 20 Hz to 1 MHz.
 - b. Common-Mode Noise Attenuation: Minus 120 dBA minimum at 0.5 to 1.5 kHz; minus 65 dBA minimum at 1.5 to 100 kHz.
 - c. Normal-Mode Noise Attenuation: Minus 52 dBA minimum at 1.5 to 10 kHz.

2.5 CONTROL AND SIGNAL TRANSFORMERS

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

2.6 SOURCE QUALITY CONTROL

- A. Test and inspect transformers according to IEEE C57.12.91.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 CONNECTIONS

- A. Ground equipment according to Section 26 05 26 – Grounding and Bonding for Electrical Systems.
- B. Connect wiring according to Section 26 05 19 – Conductors and Communications Cabling.
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 ADJUSTING

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

END OF SECTION 26 22 00

SECTION 26 24 13.21 - SWITCHBOARDS

PART 1 - GENERAL

1.1 SCOPE

Furnish and install, where indicated, a free-standing, dead-front type low-voltage distribution switchboard, utilizing group mounted circuit protective devices, integrated panelboards, and other equipment as specified herein, and as shown on the contract drawings.

1.2 RELATED SECTIONS

- A. Section 26 22 00 – Low Voltage Transformers
- B. Section 26 24 16 – Low Voltage Panelboards
- C. Section 26 28 00 – Overcurrent Protective Devices

1.3 REFERENCES

- A. The low-voltage distribution switchboards and all components shall be designed, manufactured, and tested in accordance with the latest applicable following standards:
 - 1. NEMA PB-2
 - 2. UL Standard 891

1.4 SUBMITTALS – FOR REVIEW/APPROVAL

- A. The following information shall be submitted to the Engineer:
 - 1. Master drawing index
 - 2. Front view elevation
 - 3. Floor plan
 - 4. Top view
 - 5. Single line
 - 6. Schematic diagram
 - 7. Nameplate schedule
 - 8. Component list

9. Conduit entry/exit locations
 10. Assembly ratings including:
 - a. Short-circuit rating.
 - b. Voltage
 - c. Continuous current
 11. Major component ratings including:
 - a. Voltage
 - b. Continuous current
 - c. Interrupting ratings
 12. Cable terminal sizes
 13. Product data sheets
- B. Where applicable, the following additional information shall be submitted to the Engineer:
1. Busway connection
 2. Connection details between close-coupled assemblies
 3. Composite floor plan of close-coupled assemblies

1.5 SUBMITTALS – FOR CONSTRUCTION

- A. The following information shall be submitted for record purposes:
1. Final as-built drawings and information for items listed in Paragraph 1.04 and shall incorporate all changes made during the manufacturing process.
 2. Wiring diagrams
 3. Certified production test reports
 4. Installation information
 5. Seismic certification and equipment anchorage details as specified.

1.6 QUALIFICATIONS

- A. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly.
- B. For the equipment specified herein, the manufacturer shall be ISO 9001 or 9002 certified.

- C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

1.7 REGULATORY REQUIREMENTS

- A. The low-voltage switchboard shall be UL labeled.

1.8 DELIVERY, STORAGE AND HANDLING

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

1.9 OPERATION AND MAINTENANCE MANUALS

- A. Equipment operation and maintenance manuals shall be provided with each assembly shipped and shall include instruction leaflets, instruction bulletins and renewal parts lists where applicable, for the complete assembly and each major component.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Eaton
- B. Square D
- C. Siemens
- D. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the Engineer ten (10) days prior to bid date.

2.2 RATINGS

- A. The assembly shall be rated to withstand mechanical forces exerted during short-circuit conditions when connected directly to a power source having available fault current as found in the short circuit study. Main Switchboard Section shall be fully rated for 65,000 amperes symmetrical at rated voltage. Sub-panels shall be fully rated to meet requirements shown on drawings. Copies of series combinations shall be submitted with approval drawings. These series combinations are required to be tested by UL and values predicted by the use of let-through curves are not acceptable.
- B. Voltage rating to be as indicated on the drawings.

2.3 CONSTRUCTION

- A. Switchboard shall consist of the required number of vertical sections bolted together to form a rigid assembly. The sides and rear shall be covered with removable bolt-on covers. All edges of front covers or hinged front panels shall be formed. Provide adequate ventilation within the enclosure.
- B. All sections of the switchboard shall be front, and rear aligned with depth as shown on the drawings. All protective devices shall be group mounted. Devices shall be front removable and load connections front accessible enabling switchboard to be mounted against a wall.
- C. The assembly shall be provided with adequate lifting means.
- D. The switchboard shall be equal to Eaton type Pow-R-Line C utilizing the components herein specified and as shown on the drawings.

2.4 BUS

- A. All bus bars shall be silver-plated copper. Main horizontal bus bars, if applicable, shall be mounted with all three phases arranged in the same vertical plane. Bus sizing shall be based on NEMA standard temperature rise criteria of 65 degrees C over a 40 degrees C ambient (outside the enclosure).
- B. Provide a full capacity neutral bus where a neutral bus is indicated on the drawings.
- C. A copper ground bus (minimum 1/4 x 2 inch) shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the switchboard.
- D. All hardware used on conductors shall be high-tensile strength and zinc-plated. All bus joints shall be provided with conical spring-type washers.

2.5 WIRING/TERMINATIONS

- A. Small wiring, necessary fuse blocks and terminal blocks within the switchboard shall be furnished as required. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer's wiring diagrams.
- B. Mechanical-type terminals shall be provided for all line and load terminations suitable for copper or aluminum cable rated for 75 degrees C of the size as indicated on the drawings.
- C. Lugs shall be provided in the incoming line section for connection of the main grounding conductor. Additional lugs for connection of other grounding conductors shall be provided as indicated on the drawings.
- D. All control wire shall be type SIS, bundled and secured with nylon ties. Insulated locking spade terminals shall be provided for all control connections, except where saddle type terminals are provided integral to a device. All current transformer secondary leads shall first be connected to conveniently accessible short-circuit terminal blocks before connecting to any other device. All groups of control wires leaving the switchboard shall be provided with terminal blocks with suitable numbering strips. Provide wire markers at each end of all control wiring.

- E. Where there is a main switchboard section in the lineup, the switchboard manufacturer shall wire from the associated feeder breaker to the respective panelboard, dry type distribution transformer, automatic transfer switch, UPS, etc... as noted on drawings. Feeders shall be copper, and conductor sized as noted on the drawings. This wiring shall be installed in the factory and shall not be installed in the field. All factory installed power wiring shall be provided with phase color tape as follows:

1. 480/277-Volt WYE Systems
 - a. Phase-A = Brown
 - b. Phase-B = Orange
 - c. Phase-C = Yellow
 - d. Neutral = Gray
2. 208/120-Volt WYE Systems
 - a. Phase-A = Black
 - b. Phase-B = Red
 - c. Phase-C = Blue
 - d. Neutral = White

2.6 MAIN SWITCHBOARD SECTION

- A. The following shall be provide as indicated on the contract drawings
1. Main protective devices
 2. Trip units – Main and Tie devices
 3. Feeder protective devices
 4. Trip units – Feeder devices
 5. Accessories
 - a. Provide shunt trips, bell alarms and auxiliary switches as shown on the contract drawings.

2.7 INTEGRATED PANELBOARDS

- A. The switchboard manufacturer shall integrate and assemble panelboards into the switchboard as shown on the contract drawings. Each panelboard shall contain a trim with lockable door. The panel shall be recessed in the switchboard enclosure a minimum of four inches from the front of the switchboard to allow easy access to line and/or load conductors entering/exiting top of bottom. Trim doors shall be laser cut to assure proper fit. Three quarter inch (3/4-inch) breakers shall not be used in any part of the panelboard.

- B. The Switchboard shall accommodate two (2) 42-circuit panelboards (225-Amp Main Circuit Breaker or 400-Amp Main Lug Only) per structure, or one, full-height molded case breaker distribution chassis and one (1) 42-circuit panelboard..
- C. Integrated panelboards shall be equal to Eaton Pow-R-Line type. Ratings of the panelboards shall meet marked ratings of the switchboard.
- D. Panelboards shall meet criteria as shown in Section 26 24 16 – Low Voltage Panelboards.
- E. Panelboards shall have a wire management system inside wire way to accommodate branch circuit wiring passing through vertically in that section.

2.8 ENCLOSURES

- A. NEMA 1 Enclosure

2.9 NAMEPLATES

- A. Engraved nameplates, mounted on the face of the assembly, shall be furnished for all main and feeder circuits as indicated on the drawings. Nameplates shall be laminated plastic, black characters on white background. Characters shall be 3/16-inch high, minimum. Nameplates shall give item designation and circuit number as well as frame ampere size and appropriate trip rating. Furnish master nameplate giving switchboard designation, voltage ampere rating, short-circuit rating, manufacturer's name, general order number, and item number.
- B. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer's wiring diagrams.

2.10 FINISH

- A. All exterior and interior steel surfaces of the switchboard shall be properly cleaned and provided with a rust-inhibiting phosphatized coating. Color and finish of the switchboard shall be ANSI 61 light gray.

2.11 SURGE PROTECTIVE DEVICES

- A. Provide surge protective devices as specified in Contract Documents and applicable code.

PART 3 - - EXECUTION

3.1 FACTORY TESTING

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

1. The switchboard shall be completely assembled, wired, adjusted, and tested at the factory. After assembly, the complete switchboard will be tested for operation under simulated service conditions to assure the accuracy of the wiring and the functioning of all equipment. The main circuits shall be given a dielectric test of 2200 volts for one (1) minute between live parts and ground, and between opposite polarities. The wiring and control circuits shall be given a dielectric test of 1500 volts for one (1) minute between live parts and ground.

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

3.2 MANUFACTURER'S CERTIFICATION

- A. A certified test report of all standard production tests shall be available to the Engineer upon request.

3.3 TRAINING

- A. The Contractor shall provide a training session for up to five (5) owner's representatives for 1 normal workdays at a jobsite location determined by the owner.
- B. A manufacturer's qualified representative shall conduct the training session. The training program shall consist of instruction on operation of the assembly, circuit breakers, fused switches, and major components within the assembly.

3.4 INSTALLATION

- A. The Contractors shall install all equipment per the manufacturer's instructions, contract drawings and National Electrical Code.
- B. The assembly shall be provided with adequate lifting means and shall be capable of being moved into installation position and bolted directly to Contractor supplied floor sills to be set level in concrete per manufacturer's recommendations. All necessary hardware to secure the assembly in place shall be provided by the Contractor.

3.5 FIELD ADJUSTMENTS

- A. The Contractor shall perform field adjustments of the protective devices as required to place the equipment in final operating condition. The settings shall be in accordance with the approved short-circuit study, protective device evaluation study and protective device coordination study.
- B. Necessary field settings of devices and adjustments and minor modifications to equipment to accomplish conformance with an approved short circuit and protective device coordination study shall be carried out by the Contractor at no additional cost to the owner.

END OF SECTION 26 24 13.21

SECTION 26 24 16 – LOW VOLTAGE PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Contract Documents including drawings and general provisions of the Contract, including General and Supplementary Conditions and specification sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes load centers and panelboards, overcurrent protective devices, and associated auxiliary equipment rated 600 V and less for the following types:

- 1. Branch-circuit panelboards.

1.3 REFERENCES

- A. The following is a list of standards which may be referenced in this section:

- 1. Institute of Electrical and Electronics Engineers (IEEE):
 - a. C62.1, Surge Arresters for Alternating Current Power Circuits.
 - b. C62.11, Standards for Metal-Oxide Surge Arrestors for AC Power Circuits.
- 2. National Electrical Contractor's Association (NECA): 407, Recommended Practice for Installing and Maintaining Panelboards.
- 3. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
 - b. 289, Application Guide for Ground Fault Circuit Interrupters.
 - c. AB 1, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.
 - d. KS 1, Enclosed Switches.
 - e. LA 1, Surge Arrestors.
 - f. PB 1, Panelboards.
 - g. PB 1.1, General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
- 4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).

5. Underwriters Laboratories Inc. (UL):
 - a. 67, Standard for Panelboards.
 - b. 98, Standard for Enclosed and Dead-Front Switches.
 - c. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
 - d. 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
 - e. 508, Standard for Industrial Control Equipment.
 - f. 870, Wireways, Auxiliary Gutters and Associated Fittings.
 - g. 943, Standard for Ground-Fault Circuit-Interruptioners.

1.4 SUBMITTALS

- A. Product Data: For each type of panelboard, overcurrent protective device, TVSS device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each panelboard and related equipment.
 1. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Enclosure types and details for types other than NEMA 250, Type 1.
 - b. Bus configuration, phase, frequency, current, and voltage ratings.
 - c. Short-circuit current rating of panelboards and overcurrent protective devices.
 - d. UL listing.
 - e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - f. Provisions for circuit terminations with wire range.
 2. Wiring Diagrams: Diagram power, signal, and control wiring and differentiate between manufacturer-installed and field-installed wiring.
- C. Panelboard Schedules: For installation in panelboards. Scheduling shall be typewritten indicating loads served by each breaker.

- D. Maintenance Data: For panelboards and components to include in maintenance manuals. In addition to requirements specified in the Contract Documents, include the following:
 - 1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 - 2. Time-current curves, including selectable ranges for each type of overcurrent protective device.

1.5 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Panelboards, Overcurrent Protective Devices, Controllers, Contactors, and Accessories:
 - a. Eaton Electrical
 - b. General Electric Co.; Electrical Distribution & Control Div.
 - c. Siemens Energy & Automation, Inc.
 - d. Square D Co.
 - e. Or equal.
 - 2. Panelboards shall be of the same manufacturer as equipment furnished for Low-Voltage Motor Control Centers and Medium-Voltage Motor Control Centers for standardization.

2.2 FABRICATION AND FEATURES

- A. Enclosures: Flush or Surface mounted cabinets as indicated. NEMA PB 1, Type to meet environmental conditions at installed location.
 - 1. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.
 - 2. Outdoor Locations: NEMA 250, Type 3R.

3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
4. Indoor Dry Locations: NEMA 250, Type 1.
- B. Front: Secured to box with piano hinged door in door trim. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
- C. Finish: Manufacturer's standard enamel finish over corrosion-resistant treatment or primer coat.
- D. Directory Card: With transparent protective cover, mounted inside metal frame, inside panelboard door.
- E. Bus:
 1. Material: Tin-plated copper full sized throughout length.
 2. Provide for mounting of future protective devices along full length of bus regardless of number of units and spaces shown. Machine, drill, and tap as required for current and future positions.
- F. Main, feed-through and Neutral Lugs: Shall be replaceable, bolted mechanical or crimp compression type suitable for use with conductor material.
- G. Equipment Ground Bus: Copper only Adequate for feeder and branch-circuit equipment ground conductors; bonded to box.
 1. Provide individual mechanical termination points no less than the quantity of breaker pole positions.
 2. Provide individual termination points for all other grounding conductors such as feeder, grounding electrode, etc.
- H. Neutral Terminal Bus: Copper with suitably sized provisions for termination of neutral conductors, and isolated from box.
 1. Provide individual mechanical termination points no less than the quantity of breaker pole positions.
 2. Provide individual termination points for all other neutral conductors.
- I. Gutter Barrier: Arrange to isolate individual panel sections.
- J. Wire Terminations:
 1. Panelboard assemblies, including protective devices, shall be suitable for use with 75 degrees C or greater wire insulation systems at NEC 75 degrees C conductor ampacity.
 2. In accordance with UL 486E.
- K. Load Current Ratings:

1. Unless otherwise indicated, load current ratings for panelboard assemblies, including bus and circuit breakers, are noncontinuous as defined by NEC. Continuous ratings shall be 80 percent of noncontinuous rating.
2. Where indicated “continuous”, “100 percent”, etc., selected components and protective devices shall be rated for continuous load current at value shown.

L. Overcurrent Protective Devices:

1. In accordance with NEMA AB 1, NEMA KS 1, UL 98, and UL 489.
2. Protective devices shall be adapted to panelboard installation.
 - a. Capable of device replacement without disturbing adjacent devices and without removing main bus.
 - b. Spaces: Cover openings with easily removable cover.
3. Devices shall be fully rated; series-connected ratings unacceptable.

M. Circuit Breakers:

1. General: Thermal-magnetic unless otherwise indicated, quick-make, quick-break, molded case, of indicating type showing ON/OFF and TRIPPED positions of operating handle.
2. Noninterchangeable: In accordance with NEC.
3. Bus Connection: Bolt-on circuit breakers in all formats for branch circuit panelboards.
4. Trip Mechanism:
 - a. Individual permanent thermal and magnetic trip elements in each pole.
 - b. Variable magnetic trip elements with a single continuous adjustment 3X to 10X for frames greater than 100 amps.
 - c. Two and three pole, common trip.
 - d. Automatically opens all poles when overcurrent occurs on one pole.
 - e. Test button on cover.
 - f. Calibrated for 40 degrees C ambient, unless shown otherwise.
5. Unacceptable Substitution:
 - a. Do not substitute single-pole circuit breakers with handle ties for multi-pole breakers.
 - b. Do not use tandem or dual circuit breakers in normal single-pole spaces.

6. Ground Fault Circuit Interrupter (GFCI): Where indicated, equip breaker as specified above with ground fault sensor and rated to trip on 5-mA ground fault within 0.025 second (UL 943, Class A sensitivity, for protection of personnel).
 - a. Ground fault sensor shall be rated same as circuit breaker.
 - b. Push-to-test button.
 - c. Reset button.
 7. Equipment Ground Fault Interrupter (EGFI): Where indicated, equip breaker specified above with ground fault sensor and rated to trip on 30-mA ground fault (UL listed for equipment ground fault protection).
- N. Provision for Future Devices: Equip with mounting brackets, bus connections, and necessary appurtenances for future protective device ampere ratings indicated.
- O. Special Features:
1. Service Equipment Approval: Listed for use as service equipment for panelboards having service disconnecting means.
 2. Arc Flash: Provide arc flash reduction maintenance system on service entrance main breakers.
 - a. System shall not compromise breaker phase protection when enabled.
 - b. Clearing time of 0.04 seconds, adjustable 2.5X to 10X of the sensor value.
 - c. Enabled via door mounted lockable lockout/tagout selector switch with confirmation via a blue LED indication lamp.
 - d. All indicating lamps shall have an integrated lamp-test function or a common lamp test switch for all lamps.
 - e. Provide associated control power transformer as required.
 3. Surge Arresters:
 - a. In accordance with NEMA LA 1, IEEE C62.1, and IEEE C62.11.
 - b. Comply with Section 26 43 13 – Transient-Voltage Suppression for Low-Voltage Electrical Power Circuits.
 - c. Coordinate impulse sparkover voltage with system voltage.
 - d. Provide protective device within panelboard as disconnecting means and short circuit protection per manufacturer's recommendation.
 - e. Provide factory mounting within panelboard utilizing UL-recognized mounting device.

2.3 PANELBOARD SHORT-CIRCUIT CURRENT RATING (SCCR)

- A. Fully rated to interrupt symmetrical short-circuit current available at terminals, unless otherwise stated. Series rating not allowed.
- B. Integrated equipment short circuit rating for each panelboard assembly shall be no less than the following:
 - 1. Minimum SCCR at 208Y/120 or 120/240 volts shall be 18,000 amperes rms symmetrical.
 - 2. Minimum SCCR at 480Y/277 volts shall be 65,000 amperes rms symmetrical.

2.4 LOAD CENTERS - NOT ALLOWED.

2.5 BRANCH-CIRCUIT PANELBOARDS

- A. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- B. Protective Device Locking: Furnish provisions for handle padlocking for main and subfeed devices; also provide for branch devices where indicated.
- C. NEMA 250 Type 1 Branch Panelboard Enclosure:
 - 1. Front trim shall be secured to box with concealed trim clamps.
 - 2. Surface-mount panelboard front trim shall have same dimensions as box.
 - 3. Flush panelboards front trims shall overlap box nominal 3/4 inch on all sides.
 - 4. Door in panelboard front trim, with concealed hinges, shall provide access to protective device operating handles.
 - 5. Doors over 30 inches in height shall have multi-point latching.
 - 6. Door lock shall be secure with flush catch and tumbler lock; all panelboards keyed alike, with two milled keys each lock.
 - 7. Circuit Directory: Provide with transparent plastic face and enclosed card, mounted inside each panel door.
 - 8. Hinged Front Cover (Door In Door): Entire front trim hinged to surface box with standard door within hinged trim cover.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install panelboards and accessories according to NEMA PB 1.1.
- B. Mounting Heights: Top of trim 74 inches (1880 mm) above finished floor, unless otherwise indicated.
- C. Mounting: Plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.
- D. Circuit Directory: Use a computer or typewriter to create directory; handwritten directories are not acceptable.
- E. Install filler plates in unused spaces.
- F. Provision for Future Circuits at Flush Panelboards: Stub three 3/4-inch (19 mm) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 3/4-inch (19 mm) empty conduits into raised floor space or below slab not on grade.
- G. Ground Fault Protection: Install panelboard ground fault circuit interrupter devices in accordance with installation guidelines of NEMA 289.
- H. Wiring in Panel Gutters: Train conductors neatly in groups; bundle, and wrap with nylon wire ties.

3.2 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, components, and neutral wires; provide warning signs as specified in Section 26 05 04 – Basic Electrical Materials and Methods.
- B. Panelboard Nameplates: Label each panelboard with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.3 CONNECTIONS

- A. Install equipment grounding connections for panelboards with ground continuity to main electrical ground bus.
- B. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

- A. Testing: After installing panelboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
 - 1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, section 7.5 for switches and section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.5 ADJUSTING

- A. Set field-adjustable switches and circuit-breaker trip ranges.

3.6 CLEANING

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

END OF SECTION 26 24 16

SECTION 26 24 19 – LOW-VOLTAGE MOTOR-CONTROL

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes motor-control centers for use on ac circuits rated 600 V and less.

1.2 REFERENCES

- A. As specified in Section 26 05 00 – General Requirements for Electrical Work.
- B. The following is a list of standards which may be referenced in this section:
1. American national Standard Institute (ANSI):
 - a. C2, National Electrical Safety Code (NEC)
 - b. C57.12.28, Switchgear and Transformers – Pad-Mounted Equipment – Enclosure Integrity.
 - c. Z55, Gray Finishes for Industrial Apparatus and Equipment.
 2. National Electrical Manufacturers Association (NEMA)
 - a. AB1, Molded Case Circuit Breakers.
 - b. ICS 1, General Standards for Industrial Control and Systems.
 - c. ICS 2, Standards for Industrial Control Devices, Controllers, and Assemblies.
 - d. ICS 2.3, Instructions for Handling, Installation, Operation, and Maintenance of Motor Control Centers.
 - e. ICS 2-322, AC General Purpose Motor Control Centers
 - f. KS 1, Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
 - g. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
 3. National Fire Protection Association (NFPA 70): National Electrical Code (NEC).
 4. Underwriters Laboratories, Inc. (UL):
 - a. 98, Standard for Safety Enclosed and Dead-Front Switches.
 - b. 489, Standard for Safety Molded Case Circuit Breakers and Circuit Breaker Enclosures.
 - c. 845, Standard for Safety Motor Control Centers.
 - d. Uniform Building Code (UBC):

1.3 DESIGN REQUIREMENTS

- A. Provide MCC based upon applicable NEMA and UL standards and in accordance with the detailed contract specifications and drawings.
- B. Equipment Specified in Other Division 26 Specifications: Low voltage motor control manufacturer shall be the same manufacturer as panelboards and medium voltage motor control center for standardization.
- C. Ethernet IP Protocol: All Ethernet connected terminal equipment specified herein shall be provided with a native Ethernet IP port. Separate protocol converters and gateways used to convert from other protocols will not be accepted.
- D. Motor Controller Units: Unit elements shall be of the same manufacturer as the motor control centers. Variance may only be considered to meet Ethernet IP protocol requirements.
- E. The contractor shall confirm motor full-load amperage ratings and provide those to the MCC manufacturer to ensure proper sizing of the motor branch circuit and overload protection.

1.4 SUBMITTALS

- A. Product Data: For each type of controller and each type of motor-control center. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each motor-control center.
 - 1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Each installed unit's type and details.
 - b. Nameplate legends.
 - c. Short-circuit current ratings of buses and installed units.
 - d. Vertical and horizontal bus capacities.
 - e. Features, characteristics, ratings, and factory settings of each motor-control center unit.
 - f. Conduit entrance locations
 - g. One-line diagrams
 - 2. Wiring Diagrams: Power, signal, and control wiring for class and type of motor-control center. Differentiate between manufacturer-installed and field-installed wiring. Provide schematic wiring diagram for each type of controller.
- C. Qualification Data: For firms and persons specified in "Quality Assurance" Article.
- D. Field Test Reports: Written reports specified in Part 3.

- E. Manufacturer's field service report.
- F. Maintenance Data: For motor-control centers, all installed devices, and components to include in maintenance manuals specified in Section 26 05 00 – General Requirements for Electrical Work. In addition to requirements specified elsewhere, include the following:
 - 1. Routine maintenance requirements for motor-control centers and all installed components.
 - 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
- G. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.
- H. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dipswitch settings for motor running overload protection suit actual motor to be protected.
- I. Anchoring instructions and details.
- J. Manufacturer's installation instructions.
- K. Letter of coordination from the MCC manufacturer stating that the Transient Voltage Suppression System selected for the MCC has been coordinated with and will not adversely affect the active harmonic filter.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Maintain, within 200 miles of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.
- B. Source Limitations: Obtain controllers of a single type through one source from a single manufacturer.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with NFPA 70.
- E. Product Selection for Restricted Space: Drawings indicate maximum dimensions for motor-control centers, including clearances between motor-control centers, and for adjacent surfaces and other items. Comply with indicated maximum dimensions.
- F. Products manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL Listing Mark.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver motor-control centers in shipping splits of lengths, established by contractor, that can be moved past obstructions in delivery path as indicated.
- B. Handle motor-control centers according to NEMA ICS 2.3, "Instructions for the Handling, Installation, Operation, and Maintenance of Motor Control Centers." Use factory-installed lifting provisions.
- C. Store motor-control centers indoors in clean, dry space with uniform temperature to prevent condensation. Protect motor-control centers from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- D. If stored in areas subjected to weather, cover motor-control centers to protect from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install electric heating of sufficient wattage to prevent condensation.

1.7 COORDINATION

- A. Coordinate layout and installation of motor-control centers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate features of motor-control centers, installed units, and accessory devices with pilot devices and control circuits to which they connect.
- C. Coordinate features, accessories, and functions of each motor-control center, each controller, and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.
- D. The contractor shall confirm motor full-load amperage ratings and provide those to the MCC manufacturer to ensure proper sizing of the motor branch circuit and overload protection.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Motor-Control Centers with Variable-Frequency Controllers:
 - a. Allen Bradley Centerline 2100; Rockwell Automation
 - b. Eaton Freedom 2100
 - c. Approved equivalent.

2.2 MOTOR-CONTROL CENTERS

- A. Voltage Rating: 600 volts, 60 hertz, 3 phase, 3-wire.

- B. Wiring:
1. Internal wiring and provisions of or external terminations and interfacing shall be provided in strict accordance with the Control Wiring Diagrams.
 2. Provide wiring and terminals in MCC buckets in accordance with the wiring diagrams provided with the contract drawings.
 3. All starter units shall have terminal blocks for control wiring. Terminal blocks shall be provided for power wiring for starters size 2 and smaller. Motor control centers shall be provided with all necessary interconnecting wiring and interlocking. Provide a drawing pocket in each unit.
 4. Power Wire: Power wire shall be copper 90 degrees C "MTW" insulated, sized to suit load; minimum power wire size shall be No. 12 AWG copper stranded.
 5. Control Wire: Control wire shall be No. 14 AWG stranded copper wire, rated 90 degrees C and UL listed for panel wiring.
 6. Terminals: Provide crimp type terminals made from electrolytic copper, tin-plated. Provide cable termination connectors to match cable size and quantities as indicated on the drawings.
 7. Conductor Markers:
 - a. All internal wiring in MCC buckets shall be numbered with a basic wire numbering scheme. Wires which terminate on a terminal shall have the terminal number. Wires that leave the MCC shall be labeled in accordance with Section 26 05 00 – General Requirements for Electrical Work and Section 26 24 19 – Low Voltage Motor Control.
 - b. Markers used for identification shall meet the requirements of Section 26 05 00 – General Requirements for Electrical Work.
- C. Enclosures: Surface-mounted cabinets as indicated. NEMA 250, Type 1, gasketed, unless otherwise indicated to comply with environmental conditions at installed location.
1. Compartments: Modular; individual doors with concealed hinges and quick-captive screw fasteners. Interlocks on combination controller units requiring disconnecting means in off position before door can be opened or closed, except by operating a permissive release device.
 - a. Horizontal Wiring Compartments: Accessible from front, full width, top and bottom.
 - b. Vertical Wiring Compartments: Full height, isolated from unit starters with separate hinged door.
 - c. Unit Compartment: Individual compartments separated by steel barriers for each starter, feeder, or other unit capable of being wired from front without unit removal.

2. Interchangeability: Compartments constructed to allow for removal of units without disconnecting adjacent compartments, or disturbing operation of other units in motor-control center. Interchangeability of units requiring the same size compartment and constructed to permit ready rearrangement of units, such as replacing three single units with a unit requiring three spaces, without cutting or welding.
 3. Wiring Spaces: Wiring channel in each vertical section for vertical and horizontal wiring to each unit compartment; supports to hold wiring in place.
 4. Construction:
 - a. Sheet steel reinforced with channel or angle irons.
 - b. Butt sections flush, end-to-end against similar section without bolts, nuts, or cover plates causing interference.
 - c. Removable top cover plates.
 - d. Removable plates on end panels for future bus extension.
 5. Section Mounting: Removable formed-steel channel sills and lifting angles to meet specified seismic requirements.
 6. Door Interlocking: Interlock starter and feeder doors mechanically so doors cannot be opened with unit energized. Provide defeater mechanism to allow intentional access at any time.
 7. External disconnect handles, padlockable in OFF position.
 8. Cable Entrance: Main leads enter from the bottom; control and feeder circuits enter from top and bottom.
 9. Hardware for mounting future starter and feeder tap units shall be provided at compartments specified as "FUTURE" and "SPACE."
 10. Anchor Bolts: Galvanized, sized by equipment manufacturer, 1/2-inch minimum diameter.
 11. Equipment Finish:
 - a. Electroplating process applied over a rust-inhibiting phosphate base coating.
 - b. Exterior Color: ANSI Z55.1, No. 61, light gray.
- D. Short-Circuit Current Rating for Each Section: Equal to or greater than indicated available fault current in symmetrical amperes at motor-control center location.
- E. Ethernet IP Protocol: All Ethernet connected terminal equipment specified herein shall be provided with a native Ethernet IP port. Separate protocol converters and gateways used to convert from other protocols will not be accepted.
- F. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

G. Operating Conditions:

1. Ambient Temperature: Maximum 40 degrees C.
2. Equipment to be fully rated without any derating for operating conditions.

2.3 MAIN PROTECTIVE DEVICE AND FEEDER UNITS:

A. Molded Case Circuit Breaker:

1. In accordance with NEMA AB1 and UL 489.
2. Thermal magnetic trip and interrupting capacity required for connection to system with short circuit capacity indicated.
3. The tripped position shall be clearly indicated by breaker handle maintaining a position between "ON" and "OFF." All poles shall open, close, and trip simultaneously.
4. Suitable for use with 75 degrees C wire at full NEC 75 degrees C ampacity.

B. Main protective device shall be 100% rated, with frame size, solid state trip unit, rating plug, and the following fully adjustable (dynamic) trip functions: Long Time delay, Short Time Pick-up, Short Time delay, Instantaneous, Ground Fault Pick-up, and Ground Fault delay.

C. Feeder protective devices 250A and greater shall include solid state trip unit, rating plug, and fully coordinate with the main breaker.

D. Arc Flash: Provide arc flash reduction maintenance system on all main breakers and feeder breakers rated 400A or greater.

1. System shall not compromise breaker phase protection when enabled.
2. Clearing time of 0.04 seconds, adjustable 2.5X to 10X of the sensor value.
3. Enabled via door mounted lockable lockout/tagout selector switch with confirmation via a blue LED indication lamp.
4. All indicating lamps shall have an integrated lamp-test function or a common lamp test switch for all lamps.
5. Provide associated control power transformer as required.

2.4 BUSES

A. Material: Plated hard-drawn copper, 98 percent conductivity.

B. Ampacity Ratings: As indicated on drawings.

C. Vertical Power Bus:

1. Three-phase tin plated full height of section, rated 300 amperes (min).

2. Sandwich type bus insulation providing dead front construction with starter units removed except for bus stab openings.
 3. Insulated and isolated barrier complete with shutters.
- D. Neutral Buses: Full size.
- E. Equipment Ground Bus: Noninsulated, horizontal copper bus 2 by 1/4 inch (50 by 6 mm), minimum.
- F. Horizontal Power Bus:
1. Three-phase tin-plated entire width of control center, rated as indicated.
 2. Pressure type solderless lugs for each incoming line cable.
 3. Isolated from top horizontal wireway.
 4. Horizontal Bus Arrangement: Main phase, neutral and ground buses extended with same capacity the entire length of motor-control center, with provision for future extension at both ends by bolt holes and captive bus splice sections or equivalent.
- G. Short-Circuit Withstand Rating: Same as short-circuit current rating of section.
- H. Bus Bracing: 65,000 amperes rms symmetrical.

2.5 MOTOR CONTROLLER UNIT:

- A. NEMA ICS 2, Class A. Units shall provide integral phase-loss and phase-unbalance protection.
- B. Provide indicated individual components and control devices including pushbuttons, selector switches, indicating lights, control relays, time delay relays, and elapsed time meters as specified in 26 05 04 – Basic Electrical Materials and Methods.
- C. Construction:
1. Drawout combination type with stab connections for starters NEMA ICS, Size 4 and smaller.
 2. Bolt-on combination type with cable connection to riser for starters NEMA ICS, Size 5 and larger.
 3. Readily interchangeable with starters of similar size.
 4. Pull-apart unit control wiring terminal boards on all units.
- D. Electromechanical Starters:
1. NEMA ICS 2, Section 322.08 standard rating, except none smaller than NEMA ICS, size 1.
 2. Rating: HP rated at 600 volts, UL labeled for 65,000 amperes with overload protection.

3. Three-phase, non-reversing.
 4. Disconnect type: Motor circuit protector (MCP) with size based on the specific motor supplied. Trip setting shall be adjustable from 700 to 1300 percent of the motor full load amperes from the front of the breaker.
 5. Combination Full Voltage Magnetic Starter:
 - a. Control: As shown.
 6. Padlockable operating handle when de-energized.
 7. Unit door interlocked to prevent opening when disconnect is in CLOSED position.
 8. Mechanical interlocked to prevent placing disconnect in ON position when unit door is open.
 9. Minimum Dimensions: 12 inches high by full section width, less vertical wireway.
- E. Reduced Voltage Motor Starter
1. Service factor: 1.15.
 2. Starting duty: Standard.
 3. Integrated solid-state reduced-voltage starter with power SCRs, logic board, paralleling bypass contactor, and electronic overload relay enclosed in a single molded housing.
 4. Communications capability via Ethernet/IP data port.
 5. Provisions to prevent false firing of SCRs due to dV/dT effects.
 6. Connections for current transformer inputs, line and load voltage inputs and SCR gate firing output circuits.
 7. Paralleling run bypass contactor:
 - a. Energize when the motor reaches 90 of full speed and close/open under one (1) times motor current.
 - b. Controller shall limit contact bounce and optimize coil voltage during varying system conditions.
 8. Face mounted digital interface module shall be used to program the soft starter. Monitoring parameters shall include line currents, pole currents, pole voltages, number of starts, and DC control voltage. Soft starter shall display motor status and the fault conditions.

9. Electronic overload protection:
 - a. Monitor all three phases individually and provide current, voltage, and power measurements via communications port.
 - b. Capable of being disabled during ramp start for long acceleration loads via digital interface module.
 - c. Adjustable via the device keypad and with motor full load ampere adjustment from 30 to 100% of the maximum continuous ampere rating of the starter.
 - d. Selectable overload class setting of 5, 10, 20 or 30.
 - e. Capable of either an electronic or mechanical reset after a fault.
 10. Protection features:
 - a. Over temperature
 - b. Line-side phase rotation
 - c. Phase loss or unbalance condition.
 - d. Motor stall condition
 - e. Motor jam condition.
 - f. Form C normally open (NO), normally closed (NC) contact that shall change state when a fault condition exists. Contacts shall be rated 60 VA (resistive load) and 20 VA (inductive load).
 11. Control features:
 - a. Selectable Torque Ramp Start or Current Limit Start
 - b. Adjustable Kick Start Time: 0–2 seconds
 - c. Adjustable Kick Start Torque: 0–85%
 - d. Adjustable Ramp Start Time: 0.5–180 seconds
 - e. Adjustable Initial Starting Ramp Torque: 0–85%
 - f. Adjustable Smooth Stop Ramp Time: 0–60 seconds.
 12. Units shall be of the same manufacturer as that of the circuit breaker and motor control center for coordination and design issues.
 13. Provide cables and necessary software to access data via portable computer.
- F. Disconnecting Device:
1. As indicated.
 2. Padlockable in OPEN position.

G. Overload Protection:

1. All motor starters shall include fully programmable electronic overload relays with I/O as shown in the Drawings.
2. Overload relays shall monitor all three phases individually for current and voltage and provide thermal overload, power measurements, ground fault detection.
3. Provide communications capability via native Ethernet/IP data port.
4. Provide CT's as required for motor load.
5. User interface shall be accessible without opening the cubicle door.
6. Protective functions:
 - a. Thermal overload
 - b. Jam
 - c. Over/under current
 - d. Current unbalance
 - e. Phase loss
 - f. Phase reversal
 - g. Over/under voltage
 - h. Voltage unbalance
 - i. Over/under power (kW)
 - j. Power factor
7. Monitoring functions:
 - a. Phase currents
 - b. Current unbalance
 - c. Ground fault current
 - d. Over/under current trip
 - e. Thermal capacity
 - f. Phase voltage
 - g. Voltage unbalance
 - h. Over/under voltage trip
 - i. Over/under power trip

- j. Real power (kW)
 - k. Power factor
 - l. Frequency
 - m. Motor starts count
 - n. Motor starts time
 - o. Fault history
 - 8. Control functions:
 - a. Local with hardwire
 - b. Network/remote
 - c. Programmable alarms
 - d. Programmable trips
 - e. Normally open dry contact, rated 1 amp (min) at 120 VAC for remote alarming.
 - 9. Provide cables and necessary software to access data via portable computer.
 - H. Control Transformer:
 - 1. Two winding, 120-volt secondary, primary voltage to suit.
 - 2. Two current-limiting fuses for primary circuit.
 - 3. One fuse in secondary circuit.
 - 4. All fuses shall be provided with blown fuse indicators.
 - 5. Mount within starter unit.
 - 6. Sized for load shown.
- 2.6 MISCELLANEOUS:
- A. Run Time Meters:
 - 1. Run time meter (elapsed time meters) shall be 2" X 1" nominal size, rectangular case type for flush panel mounting. The meter face shall be of the style that most closely resembles the MCC indicating instruments. The meters shall have a 7-digit non-resettable register with the last digit indicating hundredths of an hour.
 - B. Nameplates: In accordance with Section 26 05 00 – General Requirements for Electrical Work.
 - 1. Each motor control center compartment shall have a nameplate designating the equipment and its identifying number and size or rating. Data shall be as shown on one-line diagrams.

2. Provide one large nameplate for each motor control center identifying the motor control center name and number with 1" lettering.
 3. Equipment titles and numbers shall be completely spelled out on nameplates or as shown on the drawings.
 4. Nameplates shall also be provided for identifying all relays and devices that are located inside the panels and shall be of the sandwich phenolic described above or approved equal.
 5. Nameplates shall be mounted in a manner or location such that other equipment or devices do not block them so they are easily viewed.
- C. Power Monitor and Display (PMD):
1. PMD shall be in accordance with Section 26 09 13 – Instrument Transformers and Meters.
- D. Ethernet/IP Communications:
1. Each electronic overload relay and power monitor (PMD) in the MCC shall be supplied with a means to communicate via Ethernet/IP protocol, and shall be networked via Ethernet switch. The MCC shall have an industrial Ethernet switch and Ethernet wiring incorporated into its design for interfacing the overload relays and meter to the facility control network.
 2. Power supplies shall have a 500 ms load ride through at full load.
 3. Ethernet cabling shall be incorporated throughout the entire lineup. All copper Ethernet cable shall be 600 V UL Shielded Category 6A.
 4. Metering and overload relays shall be connected in a star topology. Switch-to-switch connections shall be connected in a linear topology.
 5. Ethernet switch manufacturer and model – See Contract Documents.
- E. Uninterruptible Power Supply (UPS):
1. Provide UPS in motor control center to power Ethernet switch and PMD. Size for load.
 2. UPS shall be powered via 120VAC control power transformer.
 3. UPS shall be in accordance with Contract Documents.
- F. Active Harmonic Filters:
1. Provide properly sized feeder overcurrent protection and instrument transformers per Section 26 35 26 – Active Harmonic Filters. Wire current transformers via shorting block in the MCC.

- G. Transient Voltage Surge Suppressor:
1. Provide metal oxide varistor (MOV) surge protective device (SPD) integral within each motor control center per Section 26 43 13 – Transient Voltage Suppression for Low-Voltage Electrical Power Circuits.
 2. Provide protective device as disconnecting means and short circuit protection per manufacturer's recommendation.
 3. SPD type selection shall be coordinated with active harmonic filter installation to prevent mis-operation due to SPD capacitors.
 4. Mount in dedicated bucket.
- H. Spare Parts:
1. In addition to spare parts mentioned elsewhere in this section, the Contractor shall supply the following spare parts for use by the Owner:
 - a. Five spare LED lamp type used for indicating lights.
 - b. One spare control, time delay phase fail, etc. relay of each type used. or 20% whichever is the greater number.
 - c. One spare lens of each color used for indicating lights.
 - d. Five spare fuses for each fuse provided.
 - e. One spare overload relay for each type and size provided.
 - f. Spare parts shall be provided with the motor control equipment when shipped to the site.

2.7 FUNCTIONAL FEATURES

- A. Description: Modular arrangement of controllers, control devices, overcurrent protective devices, transformers, load filters, instruments, indicating panels, blank panels, and other items mounted in compartments of motor-control center.
- B. Circuit-Breaker Disconnecting Means: NEMA AB 1, motor-circuit protector with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
- C. Spare Units: Type, sizes, and ratings indicated; installed in compartments indicated "spare."
- D. Provide mechanism to completely isolate vertical bus, including stab area opening, when plug-in device is withdrawn.
- E. Spaces and Blank Units: Compartments fully bused and equipped with guide rails or equivalent, ready for insertion of draw out units.

2.8 ACCESSORIES

- A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.

2.9 FACTORY FINISHES

- A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested, motor-control centers before shipping.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. It is the Contractors' responsibility to verify that the motor starters, protection equipment, and other components, etc. provided are suitable (correct phase, voltage, starter type, correct breakers, and overload relays) for the motors and equipment loads being served.
- B. Examine areas and surfaces to receive motor-control centers for compliance with requirements, installation tolerances, and other conditions affecting performance.
 - 1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install equipment in accordance with NEMA ICS 2.3, Submittal Drawings, and Manufacturer's Instructions and Recommendations.
- B. Anchor each motor-control center assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with motor-control center mounting surface.
- C. Install motor-control centers on concrete bases.
- D. Comply with mounting and anchoring requirements. All controllers, main and branch circuit breakers, wire connections, and other devices to be front mounted and accessible unless otherwise noted.
- E. Make adjustments as necessary to wiring, conduit, disconnect devices, motor starters, branch circuit protection, and other affected material or equipment to accommodate motors actually provided under this Contract.
- F. Install equipment plumb and in longitudinal alignment with pad or wall.
- G. Coordinate terminal connections with installation of secondary feeders.
- H. Grout mounting channels into floor or mounting pads.
- I. Retighten current-carrying bolted connections and enclosure support framing and panels to manufacturer's recommendations.
- J. Cables larger than No. 6 AWG which hang from their vertical connections shall be supported within 2 feet of the connection.

3.3 CIRCUIT BREAKERS

- A. Field adjust trip settings of motor starter magnetic-trip-only circuit breakers.
- B. Adjust to approximately 11 times motor rated current.

- C. Determine motor rated current from motor nameplate following installation.

3.4 OVERLOAD RELAYS

- A. The setting of the overload relays shall be by the Contractor and adjusted based on the actual full load amperes of the motor connected to the starter.
- B. Verify overload relays operate in accordance the control strategy specified in 25 99 15 – Control Sequence.

3.5 POWER MONITORS

- A. Power monitors shall be tested for verification of correct amps, volts, hertz, power factor, and harmonics by comparison of the signal into the plant's power monitoring system with a high accuracy hand held meter.

3.6 MOTOR DATA

- A. Provide typed, self-adhesive label attached to face of each motor control starter bucket, displaying the following information:
 - 1. Motor served by tag number and equipment name.
 - 2. Nameplate horsepower.
 - 3. Motor code letter.
 - 4. Full load amperes.
 - 5. Service factor.
 - 6. Overload settings.

3.7 FIELD TESTS

- A. Motor control centers shall be tested in accordance with Section 26 08 00 – Commissioning of Electrical Systems.

3.8 MANUFACTURER'S SERVICES

- A. Furnish manufacturer's representative in accordance with Contract Documents for the following services at site or classroom as designated by Owner for minimum person-days listed below, travel time excluded:
 - 1. 3 person-days for installation inspection and prestartup classroom training.
- B. Furnish startup services and training of Owner's personnel at such times as requested by Owner to accommodate the shift schedules of Owner's operation and maintenance staff.
- C. Provide Manufacturer's Certificate of Proper Installation in accordance with Contract Documents

3.9 CONCRETE BASES

- A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.
- B. Concrete base is specified in Section 26 05 00 – General Requirements for Electrical Work and concrete materials and installation requirements are specified in Contract Documents.

3.10 IDENTIFICATION

- A. Identify motor-control center, motor-control center components, and control wiring according to Section 26 05 00 – General Requirements for Electrical Work.
- B. Operating Instructions: Frame printed operating instructions for motor-control centers, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of motor-control centers.

3.11 CONNECTIONS

- A. Coordinate conduit installations and specialty arrangements with schematics on Drawings and with requirements specified. If Drawings are explicit enough, these requirements may be reduced or omitted.
- B. Conduit installation requirements are specified in other Division 26 Sections. Drawings indicate general arrangement of conduit, fittings, and specialties.
- C. Ground equipment according to Section 26 05 00 – General Requirements for Electrical Work.

3.12 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Test insulation resistance for each motor-control center element, bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.

END OF SECTION 26 24 19

SECTION 26 27 26 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes receptacles, connectors, switches, and finish plates.

1.3 DEFINITIONS

- A. GFCI: Ground-fault circuit interrupter.

1.4 SUBMITTALS

- A. Product Data: For each product specified.
- B. Shop Drawings: Legends for receptacles and switch plates.
- C. Maintenance Data: For materials and products to include in maintenance manuals specified in Contract Documents.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.
- B. Comply with NEMA WD 1.
- C. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Wiring Devices:
 - a. Cooper Wiring Devices
 - b. Hubbell, Inc.; Wiring Devices Div.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour/Legrand; Wiring Devices Div.
 - e. Approved equal.

2. Wiring Devices for Hazardous (Classified) Locations:
 - a. Crouse-Hinds Electrical Co.; Distribution Equipment Div.
 - b. Killark Electric Manufacturing Co.
 - c. Pyle-National, Inc.; an Amphenol Co.
 - d. Approved equal.
3. Multioutlet Assemblies:
 - a. Hubbell, Inc.: Wiring Devices Div.
 - b. Wiremold.
 - c. Approved equal.

2.2 RECEPTACLES (WHITE)

- A. Straight-Blade and Locking Receptacles: Industrial grade Leviton 5362 or equal.
- B. GFCI Receptacles: Feed-through type, with integral NEMA WD 6, Configuration 5-20R duplex receptacle. Do not connect downstream receptacles to load side of GFCI. Design units for installation in a 2-3/4-inch-deep outlet box without an adapter.
- C. Receptacle, Corrosion-Resistant:
 1. Meet requirements of general-purpose receptacle.
 2. Nickel coated metal parts.
- D. Receptacle, Special-Purpose:
 1. General:
 - a. Rating and number of poles as indicated or required for anticipated purpose.
 - b. Provide matching plug with cord-grip features for each special-purpose receptacle.
 2. Standard Duty Receptacles and Plugs:
 - a. General: Provide for process motor applications where shown.
 - b. Rating: Voltage and ampere ratings as shown.
 - c. Each receptacle shall be provided with an inlet plug.
 - d. Provide handles, adapter plates, metal angle adapters, cord grips, dead front safety shutter, closed lid configuration and accessories as required for the installation.

- e. Plugs and receptacles shall include auxiliary contacts for motor temperature and motor space heater use where applicable.
 - f. Manufacturers:
 - 1) Meltric; DR series, or equivalent.
- E. Hazardous (Classified) Location Receptacles: Comply with NEMA FB 11.
- 1. Contain integral switch which must be closed to energize circuit.
 - 2. Design shall permit only an approved plug to be energized.
 - a. Actuation of switch shall require plug be inserted and rotated approximately 45 degrees.
 - b. Plug shall lock into this position preventing unintended disengagement.
 - c. To remove, plug shall be turned opposite direction as engagement and pulled straight out.
- F. General Purpose Receptacle, Explosion Proof, 125 Volts, 20 Amps:
- 1. Dead front, interlocked, circuit breaking.
 - 2. Receptacle Cover: Spring loaded closes when plug is removed.
 - 3. Enclosure: Corrosion-resistant, aluminum alloy with less than 0.4 percent copper.
 - 4. Finish: Electrostatically applied and baked powder epoxy/polyester.
 - 5. External Hardware: Type 316 stainless steel.
 - 6. Switch Chamber: Factory sealed to contain switch's arcing components
 - 7. Hazardous Area Ratings: Suitable for Class I, Division 2, NEMA 7BCD, 9FG.
 - 8. Provide matching plug with each receptacle.
 - 9. Manufacturers and Products:
 - a. Cooper Crouse-Hinds; Ark Guard 2, Series ENR.
 - b. EGS/Appleton Electric; U-Line.
 - c. Killark, a division of Hubbell Inc.; UGR/UGP.
 - d. Approved equal.
- G. Ground Fault Circuit Interrupter (GFCI), Explosion-Proof:
- 1. Meet requirements of general-purpose receptacle, except as otherwise indicated.
 - 2. Hazardous Area Ratings: NEMA 7D suitable for Class I, Group C and Group D, Class 2, Groups F and G, and Class 3 locations.

3. Provide matching plug with each receptacle.

2.3 SWITCHES (WHITE)

- A. Toggle Switches: Commercial-duty, quiet type.
 1. Single Pole Switch: 20 A, 120/277-V AC. Leviton CSB 120 or approved equal.
 2. 3-Way Switch: 20A 120/277-V AC: Leviton CSB 320 or approved equal.

2.4 SWITCH, MOTOR RATED:

- A. Type: Two-pole or three-pole, manual motor starting/disconnect switch without overload protection.
 1. UL 508 listed.
 2. Totally enclosed snap-action switch. Quick-make, slow-break design with silver alloy contacts.
 3. Minimum General Purpose Rating: 30 amperes, 600V ac.
 4. Minimum Motor Ratings:
 - a. 2 horsepower for 120V ac, single-phase, two-pole.
 - b. 3 horsepower for 240V ac, single-phase, two-pole.
 - c. 15 horsepower for 480V ac, three-phase, three-pole.
 5. Screw-type terminal.

2.5 MANUALLY OPERATED STARTER

- A. Fractional Horsepower:
 1. Rating: 16 amperes continuous at 277 volts maximum.
 2. Single-phase, non-reversing, full voltage with overload protection.
 3. Toggle operated.
 4. Neon Light: Red.
 5. Handle guard/lock-off plate.
 6. Manufacturer and product: Eaton type MS or equivalent.
- B. Integral Horsepower:
 1. Rating: HP rated to maximum of 10 HP at 600 volts with overload protection.
 2. Single or three-phase, nonreversing, full voltage.
 3. Control: Toggle.

4. Locking in OFF position.
5. Manufacturer and product: Eaton type B100 or equivalent.

2.6 WALL PLATES

- A. Single and combination types match corresponding wiring devices. Provide the following wall plate types:
1. Finished Spaces: Utilize SS device plates in finished spaces.
 2. Unfinished spaces: Galvanized steel
 3. Exterior continuous use: Die cast aluminum with 3-1/2" deep "in-use" flip cover and weather-resistant gasket.
 4. Interior wet/corrosive areas: Die cast aluminum with 3-1/2" deep "in-use" flip cover and weather resistant gasket.
 5. Weatherproof:
 - a. Receptacle, Weatherproof Type 1:
 - 1) Gasketed, cast-aluminum, with individual cap over each receptacle opening.
 - 2) Mounting Screw and Cap Spring: Stainless steel.
 - b. Switch:
 - 1) Gasketed, cast-metal or cast-aluminum, incorporating external operator for internal switch.
 - 2) Mounting Screw: Stainless steel.

2.7 OCCUPANCY SENSOR, WALL SWITCH

- A. Description:
1. Passive-infrared type, 120/277-volt, adjustable time delay up to 30 minutes, 180-degree field of view, with a minimum coverage area of 900 square feet (84 square meters).
 2. Provide dual switch unit where indicated.
 3. Color: Manufacturer's standard white.

2.8 FINISHES

- A. Color: SS unless otherwise indicated or required by Code.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install devices and assemblies plumb and secure.
- B. Install wall plates when painting is complete.
- C. Install wall dimmers to achieve indicated rating after derating for ganging as instructed by manufacturer.
- D. Do not share neutral conductor on load side of dimmers.
- E. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical, and grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.
- F. Protect devices and assemblies during painting.

3.2 IDENTIFICATION

- A. Comply with Section 26 05 00 – General Requirements for Electrical Work.
- B. Use UV rated tape labels for identification of individual wall switches and receptacles in dry indoor locations.
 - 1. Degrease and clean device plate surface to receive tape labels.
 - 2. Use 3/16-inch Kroy black letters on white background, unless otherwise indicated.
 - 3. Identify panelboard and circuit number from which item is served on face of plate.
- C. Identify conductors with durable wire markers or tags inside outlet boxes.
- D.

3.3 CONNECTIONS

- A. Connect wiring device grounding terminal to outlet box with bonding jumper.
- B. Connect wiring device grounding terminal to branch-circuit equipment grounding conductor.
- C. Tighten electrical connectors and terminals according to manufacturers published torque-tightening values. If manufacturers torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections, and prepare test reports.
- B. Test Instrument for 125-Volt 20-Amp Receptacle: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.
- C. Using test plug, verify device and its outlet box are securely mounted.

- D. Line Voltage Range: 105 volts to 132 volts.
- E. Percent Voltage Drop under 15-Amp Load: Less than 6 percent; 6 percent or higher is not acceptable.
- F. Ground Impedance: 2 ohms, maximum.
- G. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943. Test GFCI operation with both local and remote fault simulations according to manufacturer's written instructions.
- H. Check TVSS receptacle indicating lights for normal indication.
- I. Tests shall be diagnostic, indicating damaged conductors, high resistance at circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

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 (OCPDs) rated 600 V and below and switching devices commonly used with them.

1.2 SUBMITTALS

- A. General: Submit the following in accordance with Contract Documents.
- B. Product data for fuses, fusible switches, circuit breakers, and OCPD accessories specified in this Section, including descriptive data.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Cartridge Fuses:
 - a. Bussmann Div., Cooper Industries, Inc.
 - b. Gould Inc.
 - c. Littelfuse Inc.
 - d. Approved equal
 - 2. Fusible Switches:
 - a. General Electric Co.
 - b. Square D Co.
 - c. Siemens
 - d. Eaton
 - e. Approved equal
 - 3. Molded-Case Circuit Breakers:
 - a. General Electric Co.
 - b. Square D Co.
 - c. Siemens

- d. Eaton
- e. Approved equal
- 4. Combination Circuit Breaker and Ground Fault Circuit Interrupters:
 - a. General Electric Co.
 - b. Square D Co.
 - c. Siemens
 - d. Eaton
 - e. Approved equal
- 5. Molded-Case Circuit Breakers With Solid-State Trip Devices:
 - a. General Electric Co.
 - b. Square D Co.
 - c. Siemens
 - d. Eaton
 - e. Approved equal

2.2 OVERCURRENT PROTECTIVE DEVICES (OCPD'S), GENERAL

- A. General: Provide OCPD's in indicated types, as integral components of panelboards, switchboards, and also as individually enclosed and mounted single units.
- B. Enclosures: NEMA 250 "Enclosures for Electrical Equipment (1,000 Volts Maximum)."

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. Class RK1 and RK5 Dual Element Time-Delay Fuses: UL 198E, "Class R Fuses."

2.4 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. Padlocking Provisions: For 2 padlocks, whether open or closed.
- H. Enclosure for Independent Mounting: NEMA Type 1 enclosure except as otherwise indicated or required to suit environment where located.

2.5 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: Bolt-in type, except breakers 225-ampere frame size and larger 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 of 10,000 amperes symmetrical, unless a greater rating as indicated.
- D. Tripping Device: Quick-make, quick-break toggle mechanism with inverse-time delay and instantaneous overcurrent trip protection for each pole.
- E. Adjustable Instantaneous Trip Devices: Factory adjusted to low-trip-setting current values.
- F. Enclosure for Independent Mounting: NEMA Type 1 enclosure, except as otherwise indicated or required to suit environment where located.
- G. Combination Circuit Breakers and Ground Fault Circuit Interrupters: 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:
 - 1. Match features and module size of panelboard breakers and provide clear identification of ground fault trip function.
 - 2. Trip Setting for Ground Fault: 30 milliamperes.

2.6 OCPD ACCESSORIES

- A. Shunt-Trip Devices for Circuit Breakers: Where indicated, arrange to trip breaker from an external source of power through a control switch or relay contacts.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Independently Mounted OCPD's: Locate as indicated and install in accordance with manufacturer's written installation instructions.
- B. OCPD's in distribution equipment shall be factory installed.

3.2 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 tightening values. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A and UL 486B.

3.3 GROUNDING

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

3.4 FIELD QUALITY CONTROL

- A. Visual and mechanical inspection: Include the following inspections and related work.
 - 1. Overcurrent-Protective-Device Ratings and Settings: Verify indicated ratings and settings to be appropriate for final system arrangement and parameters. Where discrepancies are found, test organization shall recommend final protective device ratings and settings. Use accepted revised ratings or settings to make the final system adjustments.
 - 2. Inspect for defects and physical damage, NRTL labeling, and nameplate compliance with current single line diagram.
 - 3. Exercise and perform operational tests of all mechanical components and other operable devices in accordance with manufacturer's instruction manual.
 - 4. Check tightness of electrical connections of OCPD's with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.
 - 5. Clean OCPD's using manufacturer's approved methods and materials.
- B. Retest: Correct deficiencies identified by tests and observations and provide retesting of OCPD's. Verify by the system tests that specified requirements are met.

3.5 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.

END OF SECTION 26 28 00

SECTION 26 29 13.13 - ACROSS-THE-LINE-MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Contract Documents including drawings and general provisions of Contract, including General and Supplementary Conditions and Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes A.C. motor control devices rated 600 V and below that are not supplied as an integral part of a motor control center.
- B. Related Sections include the following:
 - 1. Section 26 05 00 – General Requirements for Electrical Work for general materials, installation methods, and labeling.

1.3 SUBMITTALS

- A. Product data for products specified in this Section. Include dimensions, ratings, and data on features and components.
- B. Maintenance Data: For products to include in the maintenance manuals specified in Contract Documents.
- C. Load Current and Overload Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain similar motor-control devices through one source from a single manufacturer.
- B. Comply with NFPA 70, UL, and NEMA.
- C. Listing and Labeling: Provide products specified in this Section that are listed and labeled.
 - 1. The Terms “Listed and Labeled”: As defined in the National Electrical Code, Article 100.

1.5 COORDINATION

- A. Coordinate features of controllers and control devices with pilot devices and control circuits provided in the Contract Documents covering control systems.

1.6 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.
 - 1. Spare Fuses: Furnish 1 spare for every 5 installed units, but not less than 1 set of 3 of each kind.
 - 2. Spare LED push to test pilot lights for each type/color.
 - 3. Run Time Meter for each motor controller provided.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Eaton
 - 2. Allen-Bradley Co.; Industrial Control Group.
 - 3. General Electric Co.; Electrical Distribution & Control Div.
 - 4. Square D Co.

2.2 MANUAL MOTOR CONTROLLERS

- A. Description: NEMA ICS 2, general purpose, Class A with toggle action and overload element.

2.3 MAGNETIC MOTOR CONTROLLERS

- A. Description: NEMA ICS 2, Class A, full voltage, nonreversing, across the line, unless otherwise indicated.
- B. Control Circuit: 120 V. Provide control power transformer integral with controller where no other supply of 120 V control power to controller is indicated. Provide control power transformer with adequate capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.
- C. Combination Controller: Factory assembled with controller and arranged to disconnect switch with or without overcurrent protection as indicated.
 - 1. Fusible Disconnecting Means: NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 947-4-1, as certified by a nationally recognized testing laboratory.
- D. Overload Relay: NEMA ICS 2, Class 10 tripping characteristics selected to protect motor against voltage unbalance and single phasing. Revise controller specifications to suit Project. Autotransformer Reduced-Voltage Controller: NEMA ICS 2, closed transition.

2.4 ENCLOSURES

- A. Description: Flush or surface mounted cabinets as indicated. NEMA 250, Type 12, unless otherwise indicated to comply with environmental conditions at installed location.
 - 1. Outdoor Locations: NEMA 250, Type 3R.
 - 2. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
 - 3. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.

2.5 ACCESSORIES

- A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.
- B. Push-Button Stations, LED Push to test Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
- C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
- D. Control Relays: Auxiliary and adjustable time-delay relays.
- E. Phase-Failure and Undervoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connection. Provide adjustable undervoltage setting.
- F. Current-Sensing, Phase-Failure Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connection; arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 percent, or loss of supply voltage; with adjustable response delay.
- G. Run Time Meter: Heavy duty with digital readout in hours.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Select features of each enclosed controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, drive, and load; and configuration of pilot device and control circuit affecting controller functions.
- B. Select horsepower rating of controllers to suit motor controlled.
- C. Use fractional-horsepower manual controllers for single-phase motors, unless otherwise indicated.
- D. Use manual controllers for 3-phase motors up to 5 hp not requiring automatic or remote control.

- E. Pushbutton Stations: In covers of magnetic controllers for manually started motors where indicated, start contact connected in parallel with sealing auxiliary contact for low-voltage protection.
- F. Hand-Off-Automatic Selector Switches: In covers of manual and magnetic controllers of motors started and stopped by automatic controls or interlocks with other equipment.

3.2 INSTALLATION

- A. Install independently mounted motor-control devices according to manufacturer's written instructions.
- B. Location: Locate controllers within sight of motors controlled, unless otherwise indicated.
- C. For control equipment at walls, bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks .
- D. Install freestanding equipment on concrete housekeeping bases conforming to Section 26 05 00 – General Requirements for Electrical Work.
- E. Motor-Controller Fuses: Install indicated fuses in each fusible switch.

3.3 IDENTIFICATION

- A. Identify motor control components and control wiring in accordance with Section 26 05 00 – General Requirements for Electrical Work.

3.4 CONTROL WIRING INSTALLATION

- A. Install wiring between motor control devices in accordance with Section 26 27 26 – Wiring Devices.
- B. Bundle, train, and support wiring in enclosures.
- C. Connect hand-off-automatic switch and other automatic control devices where available.
 - 1. Procedures: Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Section 7.5, 7.6, and 7.16. Certify compliance with test parameters.
 - 2. Remove and replace malfunctioning units with new units, and retest.

3.5 CONNECTIONS

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

3.6 FIELD QUALITY CONTROL

- A. Testing: After installing motor controllers and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Procedures: Perform each visual and mechanical inspection and electrical test stated in NeTA ATS, Sections 7.5, 7.6, and 7.16. Certify compliance with test parameters.
2. Remove and replace malfunctioning units with new units, and retest.

3.7 CLEANING

- A. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish. Clean devices internally using methods and materials as recommended by manufacturer.

END OF SECTION 26 29 13.13

SECTION 26 29 23 – LOW VOLTAGE ADJUSTABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes solid-state, pulse-width modulation (PWM) variable frequency drives (VFDs) for speed control of three-phase, induction motors. These VFDs are to be enclosed in freestanding NEMA 250, Type 12, unless otherwise indicated to comply with environmental conditions at installed location, see Electrical Drawings.
- B. VFD vendor to provide VFD that will operate at installed altitude. Vendor shall verify altitude.

1.2 SUBMITTALS

- A. Product Data: For each type of VFD, provide dimensions; mounting arrangements; location for conduit entries; shipping and operating weights; and manufacturer's technical data on features, performance, electrical ratings, characteristics, and finishes.
- B. The following shall be included in the bid package:
 - 1. Description of equipment and tests included in bid to meet the indicated power quality requirements.
 - 2. Nearest factory authorized service center meeting all points of 1.03A.
 - 3. Qualification and name of engineering and technical persons responsible for support and warranty of this project.
- C. The following shall be included in the submittal package and be approved by the engineer prior to any construction of the VFD system:
 - 1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Each installed unit's type and details.
 - b. Nameplate legends.
 - c. Short-circuit current ratings of integrated unit.
 - d. UL listing for series rating of overcurrent protective devices in combination controllers.
 - e. Features, characteristics, ratings, and factory settings of each motor-control center unit.
 - 2. Wiring Diagrams: Power, signal, and control wiring for VFD. Provide schematic wiring diagram for each type of VFD.

3. Detailed description of the filter equipment and sample graphs and data to meet IEEE 519-1992.
 4. Carrier frequency information.
 5. **Detailed description of the dv/dt filter and product data to ensure protection for motor against high frequency voltage spikes for the full operational range of switching frequencies with applied cable length to motor.**
- D. Qualification Data: For testing agency and manufacturer.
- E. Field Test Reports: Written reports specified in Part 3.04D below.
- F. Manufacturer's field service report.
- G. Operation and Maintenance Data: For VFDs, all installed devices, and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 26 05 00 – General Requirements for Electrical Work include the following:
1. Routine maintenance requirements for VFDs and all installed components.
 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

1.3 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Maintain, within 100 miles of Project site, a service center capable of providing training, parts, and 24 hour emergency maintenance and repairs.
- B. Source Limitations: Obtain VFDs of a single type through one source from a single manufacturer.
- C. The system shall be pre-integrated with the necessary harmonic mitigation equipment.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with NFPA 70, IEEE 519-1992, ANSI C37, and ANSI C57.

1.4 COORDINATION

- A. Match features of VFDs, installed units, and accessory devices with pilot devices and control circuits to which they connect.
- B. Match features, accessories, and functions of each VFD and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. Rockwell PF753 (wastewater applications; allowed for water applications as bid alternate for review)
 2. Rockwell PF755TL (water applications with large equipment requiring harmonic mitigation; allowed for water applications as bid alternate for review)

2.2 VARIABLE FREQUENCY DRIVES

- A. Description: NEMA ICS 2, IGBT, PWM, VFD; listed and labeled as a complete unit and arranged to provide variable speed of a NEMA MG 1, Design B, 3-phase, induction motor by adjusting output voltage and frequency.
- B. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.
- C. Output Rating: 3-phase; 6 to 120 Hz, with horsepower constant throughout speed range.
- D. Unit Operating Requirements:
1. Input ac voltage tolerance of 480 V, plus or minus 10 percent.
 2. Input frequency tolerance of 60 Hz, plus or minus 6 percent.
 3. Output Rating: 3-phase; 6 to 66 Hz, with amperage equal or greater to motor nameplate amperage including altitude derating.
 4. Minimum Inverter Efficiency: 96 percent at 60 Hz, full load.
 5. Minimum Displacement Primary-Side Power Factor: 96 percent lagging.
 6. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.
 7. Starting Torque: Default to be 50% with adjustment to 120%.
 8. Speed Regulation: Plus or minus 1 percent.
 9. Isolated control interface to allow controller to follow control signal over an 11:1 speed range.
- E. Internal Adjustability Capabilities:
1. Minimum Speed: 5 to 25 percent of maximum rpm.
 2. Maximum Speed: 80 to 100 percent of maximum rpm.
 3. Acceleration: Adjustable from .01 to 3600 seconds.

4. Deceleration: Adjustable from .01 to 3600 seconds.
 5. Current Limit: 50 to a minimum of 110 percent of maximum rating.
- F. Self-Protection and Reliability Features:
1. Input transient protection by means of surge suppressors.
 2. Snubber networks to protect against malfunction due to system voltage transients.
 3. Under- and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.
 4. Filtering to prevent noise interference with other electronic equipment.
 5. Motor Overload Relay: Adjustable.
 6. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
 7. Instantaneous line-to-line and line-to-ground overcurrent trips.
 8. Loss-of-phase protection.
 9. Reverse-phase protection.
 10. Short-circuit protection.
 11. Motor overtemperature fault.
- G. Automatic Reset and Restart: To attempt three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bi-directional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.
- H. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped. VFD to automatically re-start motor after outage.
- I. Carrier Frequency Adjustment: Provide ability to manually adjust drive carrier frequency. VFDs 100HP and less shall provide carrier frequency adjustment capability from 1 to 10kHz. VFDs over 100HP shall include carrier frequency adjustment information recommended by the manufacturer.
- J. Output dv/dt filter: Passive device, designed to protect AC motors from the destructive effects of peak voltages. Guaranteed to meet maximum peak motor voltage specification (150% of bus voltage) with up to 1,000 ft of cable between the filter and the motor.
1. Voltage range to meet system requirements and size to meet applied motor.
 2. Continuous current rating of 100% RMS.
 3. Intermittent current ratings of 150% for 1 minute.
 4. Intermittent current ratings of 200% for 10 seconds.

5. Rated for designed altitude.
 6. Rated for maximum ambient temperature: 50°C.
 7. Insertion Loss: 3% of rated voltage maximum.
- K. Audible Noise at two meters: 76dB-A maximum
- L. Torque Boost: Automatically vary starting and continuous torque to at least 1.5 times the minimum torque to insure high-starting torque and increased torque at slow speeds.
- M. Motor Temperature Compensation at Slow Speeds: Adjustable current fallback based on output frequency for temperature protection of self-cooled fan-ventilated motors at slow speeds.
- N. Provide load side filtering to minimize total harmonic distortion as noted on the drawings.
- O. Status Lights: Door-mounted push to test LED indicators shall indicate the following conditions:
1. Power on
 2. Run
 3. Fault
- P. Panel-Mounted Operator Station: HIM user interface screen, start-stop and auto-hand selector switches, reset button and motor hour meter (analog 24V) or 120 V. Auto-hand selector switch to be wired to terminal blocks to allow for interface with SCADA.
- Q. Indicating Devices: Digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:
1. Output frequency (Hz).
 2. Motor speed (rpm).
 3. Motor status (running, stop, and fault).
 4. Motor current (amperes).
 5. Motor torque (percent).
 6. Fault or alarming status (code).
 7. PID feedback signal (percent).
 8. DC-link voltage (VDC).
 9. Set-point frequency (Hz).
 10. Motor output voltage (V).
- R. Control Signal Interface: Provide VFD with the following:
1. Ethernet connectivity using Ethernet/IP protocol

2. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.
3. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BMS or other control systems:
 - a. 0 to 10-V dc.
 - b. 0-20 or 4-20 mA.
 - c. Fixed frequencies using digital inputs.
 - d. RS485.
 - e. Keypad display for local hand operation.
 - f. Remote start/stop input
4. Output Signal Interface:
 - a. Provide two analog output signals (0/4-20 mA), which can be programmed for the following:
 - b. Output frequency (Hz).
 - c. Output current (load).
 - d. DC-link voltage (VDC).
 - e. Motor torque (percent).
 - f. Motor speed (rpm).
 - g. Digital Output: Fault and warning indication (overtemperature or overcurrent).
5. Remote Indication Interface: Provide dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
 - a. Motor running.
 - b. Drive system is in remote via HOA switch.
- S. Integral Disconnecting Means: Provide HACR rated breaker as indicated on drawings.

2.3 ACCESSORIES

- A. Devices shall be factory installed in VFD enclosure.
- B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type. Provide LED push to test pilot lights.
- C. Run Time Meter: Heavy duty with digital readout in hours.
- D. Control Relays: Auxiliary and adjustable time-delay relays.

- E. Standard Displays:
 - 1. Output frequency (Hz).
 - 2. Set-point frequency (Hz).
 - 3. Motor current (amperes).
 - 4. DC-link voltage (VDC).
 - 5. Motor torque (percent).
 - 6. Motor speed (rpm).
 - 7. Motor output voltage (V).

- F. Historical Logging Information and Displays:
 - 1. Real-time clock with current time and date.
 - 2. Running log of total power versus time.
 - 3. Total run time.
 - 4. Fault log, maintaining last four faults with time and date stamp for each.

- G. Factory installed CR1220 battery in the I/O card (Rockwell drives).

- H. Harmonic Mitigation: Complying with IEEE Standard 519-1992 shall be a requirement of this project. Harmonic filters, 18 pulse converter configurations, phase multiplication devices, or any other components required to mitigate harmonic voltage and current to IEEE Std. 519-1992 shall be an integral part of the VFD system. Designs which are not pre-integrated and factory wired as part of the UL label will not be acceptable.
 - 1. Designs which cause voltage rise at the VFD terminals must document coordination with the total system variation to prevent nuisance tripping.
 - 2. Designs which do not provide both true and displacement, measured at the VFD terminals, of at least 95% or better at full load are not acceptable. Designs that allow leading power factor at minimum loads are not acceptable.

- I. Relevant data for VFD vendor calculations to meet IEEE Std. 519-1992 requirements are as follows:
 - 1. The point of common coupling (PCC) shall be defined per 3.01.C below.
 - 2. The calculated load current (I_L) shall be the total combined full load current of each ASD system supplied as part of this project or the total combined amperage of loads designated as “non-linear”.
 - 3. The VFD vendor is responsible for determining the short circuit current (I_{sc}) available at the PCC.

2.4 EXAMINATION

- A. Examine areas, surfaces, and substrates to receive VFDs for compliance with requirements, installation tolerances, and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Select features of each VFD to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, drive, and load.
- B. Select rating of controllers to suit motor controlled. The VFD vendor shall certify that the supplied equipment is properly matched to the loads being fed.
- C. The drive shall be capable of operating in compliance with IEEE 519-1992, with point of common coupling (PCC) defined as the point at which each individual device is connected to the electrical distribution system. Drive manufacturer shall provide harmonic calculations and on-site post installation harmonic testing with certified reports prior to final acceptance of installation. See 3.04D.

3.2 IDENTIFICATION

- A. Operating Instructions: Frame printed operating instructions for VFDs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFD units.
- B. Provide typed, self-adhesive label attached to face of each VFD, displaying the following information:
 - 1. Motor served by tag number and equipment name.
 - 2. Nameplate horsepower.
 - 3. Motor code letter.
 - 4. Full load amperes.
 - 5. Service factor.
 - 6. Overload settings.

3.3 CONNECTIONS

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

3.4 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Test insulation resistance for each VFD element, bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
 - 3. All tests necessary to prove compliance with IEEE Standard 519-1992.
- B. Testing: Perform the following field quality-control testing:
 - 1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Sections 7.5, 7.6, and 7.16. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including pretesting and adjusting VFDs.
- D. Test Reports: Prepare a written report to record the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

3.5 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 26 Sections.
- C. Complete installation and startup checks according to manufacturer's written instructions.

3.6 ADJUSTING

- A. Set field-adjustable switches.

3.7 CLEANING

- A. Clean VFDs internally, on completion of installation, according to manufacturer's written instructions. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain VFDs.

END OF SECTION 26 29 23

SECTION 26 35 26 – ACTIVE HARMONIC FILTERS (AHF)

PART 1 - GENERAL

1.1 SUMMARY

- A. This specification defines the requirements for active harmonic filter systems in order to meet IEEE-519-2014 electrical system requirements for harmonic current limits. The active harmonic filter shall have the capability to maintain power factor between 0.95 and 0.999 lagging when operated within limits. These filters are to be enclosed in freestanding NEMA 250, Type 12, unless otherwise indicated to comply with environmental conditions at installed location.
- B. The active harmonic filter shall electronically supply the non-fundamental current demanded by the non-linear load that results in a near sinusoidal current being drawn from the supply.

1.2 STANDARDS

- A. The active harmonic filter system shall be designed in accordance with the applicable sections of the following documents.
 - 1. IEEE std C62.41
 - 2. IEEE std 519-2014
 - 3. CSA 22.2: No. 14 & 16
 - 4. UL 508
 - 5. IEC 60529, IP20
 - 6. ICC IBC
 - 7. ARRA – American Recovery Investment Act
 - 8. Manufactured in the USA
 - 9. The products shall include third party approvals by cULus.

1.3 FACTORY TESTS

- A. The manufacturer shall test the system performance at rated current and voltage while functioning as a harmonic correction device prior to shipment. A certified report shall be submitted at the successful completion of factory performance tests.

1.4 SUBMITTALS

- A. Product Data: For each filter, provide dimensions; mounting arrangements; location for conduit entries; shipping and operating weights; and manufacturer's technical data on features, performance, electrical ratings, characteristics, and finishes.
- B. The following shall be included in the bid package:
 - 1. Detailed description of equipment and tests included in bid to meet the indicated power quality requirements. Include sample graphs and data to meet IEEE 519-1992.
 - 2. Nearest factory authorized service center meeting all points of 1.03A.
 - 3. Qualification and name of engineering and technical persons responsible for support and warranty of this project.
- C. The following shall be included in the submittal package and be approved by the engineer prior to any construction of the active harmonic filter system:
 - 1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Each installed unit's type and details.
 - b. Nameplate legends.
 - c. Short-circuit current ratings of integrated unit.
 - 2. Wiring Diagrams: Power, signal, and control wiring. Provide schematic wiring diagram for each type of harmonic filter.
- D. Factory test reports.
- E. Qualification Data: For testing agency and manufacturer.
- F. Field Test Reports: Written reports specified in Part 3.05D below.
- G. Manufacturer's field service report.
- H. Operation and Maintenance Data: For harmonic filters, all installed devices, and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 26 05 00 – General Requirements for Electrical Work, include the following:
 - 1. Routine maintenance requirements for active harmonic filter and all installed components.
 - 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

1.5 QUALITY ASSURANCE

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

1.6 COORDINATION

- A. Match features of AHFs, installed units, and accessory devices with communication devices and control circuits to which they connect.
- B. Coordinate placement for installation of AHFs and CTs with related equipment to ensure adequate space is available for installation.

1.7 WARRANTY

- A. Manufacturer shall warrant against defects in materials and workmanship for two (2) years.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Provide products by the following:
 - 1. Mesta
 - 2. TCI
 - 3. Or equal as approved by the engineer.

2.2 ACTIVE HARMONIC FILTERS

- A. System Description
 - 1. Voltage: 480/600 Volts, 60 Hz, 3 phase, 3 wire plus ground.
 - 2. Current Rating: Provide the rated current capacity at the voltage required, as indicated within this specification and shown on the drawings
 - 3. Current Transformers:
 - a. Two current transformers are required and mounted on phases A & C.
 - b. Current transformers are an integral part of the active harmonic filter. When current transformers are installed external to the active harmonic filter equipment, the contractor shall be responsible for the installation of manufacturer provided current transformers.

- c. Current ratings of the current transformers shall be according to full load current of the circuit on which installed. Primary rating or 500A, 1000A, 3000A, or 5000A with a secondary rating of 5A are acceptable.
- d. Current transformers rated for 400 hertz shall be used.
- e. The current transformers shall be placed as close as possible to the non-linear load to be conditioned, within manufacturer guidelines.
- f. Current transformers shall be dedicated for AHF operation and not shared with other system components.
- g. When active filters are shown to be connected for future parallel operation, CT burden rating shall be appropriate for the number of units shown.

B. Performance Requirements

1. Response Time:

- a. In a steady state condition, the active harmonic filter shall have a response time of less than one (1) line cycle.
- b. In the event of a load change or transient condition, the response time shall be within three (3) line cycles.

2. Input Power:

- a. Voltage: 480 Volt, 3 phase, 3 wire plus ground
- b. Voltage Tolerance: +/- 10% of nominal
- c. Frequency: automatically adapted to 60Hz, +/- 3%
- d. Input Circuit Breaker: 65 kAIC (min), or 100 kAIC Rated (if specified elsewhere)
- e. Surge Withstand Capability: ANSI/IEEE C62.41-1991 without damage
- f. Input Fuses: Class T rated at 200,000 AIC (amperes interrupting capacity)

3. Output Performance

- a. Performance of the active harmonic filter shall be independent of the impedance of the power source. All performance levels shall be attained whether on the AC lines, backup generator, or output of UPS.

- b. Harmonic Correction:
 - 1) Limit the 2nd through 50th order harmonic current to <5% TDD (or, if specified elsewhere, to the calculated level per IEEE std 519) at each installed location indicated herein. Levels for individual harmonic orders shall comply with respective levels established in ANSI/IEEE std 519-2014, Table 2.
 - 2) Limit the THD (V) added to the electrical system immediately upstream of the active line conditioner location(s) to less than or equal to 5%. The active harmonic filter shall not correct for utility supplied voltage distortion levels.
- c. When sized properly, reactive Current Compensation shall be capable of improving power factor to be to between 0.90 and 0.999 lagging. All linear and non-linear load must be documented.
- d. Filters shown to operate in tandem (tie closed) or independently shall have all necessary wiring to achieve this requirement.

2.3 ENCLOSURE

- A. Each filter shall be provided in a UL Type 1, 12, or 3R rated enclosure.
- B. All enclosed units shall have means to prevent the door from being opened when the unit is energized. This can be achieved by either:
 - C. A door-interlocked circuit breaker that provides power interruption when the door is opened. The circuit breaker shall be lockable in the power-off position. Units shall be disconnected from the power source by a disconnect device or circuit breaker contained in the power distribution center as defined by local and national codes for branch circuit protection.
 - D. A mechanism that locks the door when the unit is energized. The unit may be fed using an external disconnect or breaker.
- E. Freestanding units shall include lifting provisions by forklift truck and lifting lugs. Wall mount units weighing more than 80 pounds shall be equipped with a means of lifting, such as lifting lugs.
- F. Door Mounted Digital HMI Operator Interface option.
- G. All units shall be provided with 200,000 AIC rated fuses with Class T actuation and a grounding lug. Grounding by the contractor is to be performed according to local and national standards.

2.4 OPERATOR CONTROLS AND INTERFACE

- A. The active harmonic filter shall require minimal field programming.

- B. The active harmonic filter shall contain a color touch screen display with the following features:
 - 1. Easily navigable screens, including Home, Status, Fault and Setup screens.
 - 2. Display voltage and current waveform data along with RMS metering data.
 - 3. A gauge-based indicator of active filter current usage, from 0 to 100% of capacity. Dual state indications of nominal operation and “at capacity” operation.
 - 4. An alarm history buffer saved in non-volatile. Buffer information shall persist between power outages, with a minimum of 128 event entries.
 - 5. Ability to set the end user Line/Load CT ratio of the active harmonic filter system.
 - 6. The Operator Interface shall show THD, Power Factor, RMS Current, RMS Voltage, and Fault History.
- C. The active harmonic filter shall have the ability to operate in three (3) modes: i) harmonic correction only mode, ii) power factor correction only mode, or iii) combination harmonic and power factor mode. All three control modes shall be configurable from the local operator color touch screen display.
- D. The active harmonic filter shall have a configurable relay-based run/stop command input in addition to the manual and auto run/stop commands. The active filter shall have a configurable relay-based fault output. Each contact shall be rated for 2.0 Amperes at 250 volts.
- E. The filter shall have a configurable network-based run/stop command input in addition to the manual and auto run/stop commands.
- F. The filter shall have the ability to load and save operational parameters in non-volatile persistent memory and the ability to revert to factory default parameter settings.
- G. The filter shall possess an integrated industry standard serial TIA/EIA-485 / RS-485 fieldbus slave network connection such as Modbus RTU for remote monitoring and operation of the active filter.
- H. The filter shall have the ability to communicate over a standard industrial Ethernet communications network such as Ethernet/IP Modbus TCP/IP. Protocol converters and gateways used to convert from other protocols will not be accepted.
- I. The filter shall have the ability to communicate over a standard industrial Fieldbus communications network such as ethernet.
- J. The unit shall automatically begin to correct harmonic currents after power up without the need for operator intervention.
- K. The unit shall have the ability to display trend history data for line voltage, line current, filter current, current THD, filter bus voltage, and filter heatsink temperature.

2.5 DESIGN

- A. All active harmonic filters shall be defined as power electronic devices which consist of power semiconductors and a DC bus that acts to inject current into the AC line that will cancel undesirable harmonic currents drawn by the load. The system shall correct all types of nonlinear loads. A DC bus shall store power for power semiconductor switching. A digital microcontroller shall control the operation of the power converter.
- B. The active harmonic filter shall feature fully digital synchronous frame controls for selected harmonics to enhance drive load compatibility.
- C. The active harmonic filter shall feature a fully digital, broadband current regulator with progressive gains to eliminate system resonance tuning issues and simplify startup and commissioning.
- D. The active harmonic filter shall feature single processor control of all power electronic devices per a single active filter to reduce fault response latency and harmonic correction loop times
- E. Each unit shall be designed with over-current and current limiting self-protection. Operation shall continue indefinitely at manufacturer defined safe operating levels without trip off or destruction of the active harmonic filter.
- F. Large units (capacity>350A) shall have built in redundancy so at least one half of the corrective current capacity is available after a normal single point fault.
- G. All inductive elements in the power circuit of active harmonic filter shall be coreless, in order to maintain constant inductance and avoid saturation at high current levels
- H. Units shall detect heatsink temperature and have the ability to fold back the current limit based on the temperature measurement.
- I. Two distinct levels of faults shall be employed: Critical and Non-critical levels Non-critical level faults will provide automatic restart and a return to normal operation upon automatic fault clearance. Critical level faults stop the function of the unit and await operator action to restart.
 - 1. Faults such as AC line power loss shall be automatically restarted upon power restoration. Upon removal of these fault conditions, the active line conditioner shall restart without user action.
 - 2. All other faults shall be considered critical faults and stop the active harmonic filter. The run relay shall be disabled and the fault relay enabled. User shall be required to initiate a power reset (cycle power off and on) to restart the active harmonic filter.
- J. The logic of the active harmonic filter shall monitor the load current by utilizing two (2) current transformers (CTs) mounted on phases A and C to direct the function of the power electronic converter. The ratio of the two CTs shall be entered into the logic via the digital keypad/display to calibrate the operation of the power correction system.

- K. Multiple active harmonic filters may be installed in parallel to inject current. The units will function independently. If one unit is stopped or faulted, the remaining units will continue to operate normally.
- L. Individual unit characteristics, including sample drawings, weight, and watts loss, can be found in the Installation, Operation, and Maintenance Manual.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, surfaces, and substrates to receive AHFs for compliance with requirements, installation tolerances, and other conditions affecting performance.
- B. Verify that the jobsite environment can be maintained during and after installation within the service conditions required by the manufacturer.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Installation shall be in compliance with all manufacturer requirements, instructions, and contract drawings, including:
 - 1. Space surrounding the active harmonic filter to maintain adequate cooling.
 - 2. Conditioning of space surrounding the active harmonic filter enclosure to maintain the manufacturer's ambient temperature and humidity ranges.
 - 3. Accessibility of the active harmonic filter diagnostic lights and communication ports – these components shall be free from obstructions at all times.
- B. Coordinate placement and installation of CTs with related equipment. Provide conduit and cable as required for complete installation.
- C. Interface
 - 1. Provide all required cables and connectors to interface with other equipment.
 - 2. Ensure that communication connections and wiring are properly protected in accordance with manufacturer recommendations.

3.3 IDENTIFICATION

- A. Operating Instructions: Provide printed operating instructions for AHFs, including control sequences. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of AHF units.

3.4 CONNECTIONS

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

3.5 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Test insulation resistance for each AHF element, bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
 - 3. All tests necessary to prove compliance with IEEE Standard 519-1992.
- B. Testing: Perform the following field quality-control testing:
 - 1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Sections 7.5, 7.6, and 7.16. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including pretesting and adjusting AHFs.
- D. Test Reports: Prepare a written report to record the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 26 sections.
- C. Complete installation and startup checks according to manufacturer's written instructions.
- D. At a minimum, the start-up service shall include:
 - 1. Pre-power check:
 - a. Verify proper active filter installation and clearances

- b. Inspection of the filter for damage and debris
 - c. Verify critical electrical and mechanical connections are tight
 - d. Tug test internal connections and verify wiring
 - e. Update hardware if appropriate
 - f. Verification of proper power connection at filter input terminals
 - g. Verification of proper CT installations and electrical connections
2. Active harmonic filter power-up and commissioning:
- a. Power the active harmonic filter and perform operational checks
 - b. Update software if appropriate
 - c. If applicable run the filter with VFD load and tune filter to system attributes
- E. Performance measurements shall be recorded
- F. Active harmonic filter parameter listing shall be provided

3.7 ADJUSTING

- A. Set field-adjustable switches.

3.8 CLEANING

- A. Clean AHFs internally, on completion of installation, according to manufacturer's written instructions. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

3.9 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain AHFs.
- B. Provide 0.5 person days of installation inspection and prestart up training, which shall be provided in one session.

END OF SECTION 26 36 26

SECTION 26 36 00 – TRANSFER SWITCH

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Contract Documents including drawings and general provisions of the Contract, including General and Supplementary Conditions and specification sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes transfer switches rated 600 V and less.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.
- C. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces for the area/location installed.
- D. Field quality-control test reports.
- E. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in the Contract Documents, include the following:
 - 1. Features and operating sequences, both automatic and manual.
 - 2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a 100 mile radius of project location.
- B. Source Limitations: Obtain automatic transfer switches through one source from a single manufacturer.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with NEMA ICS 1.

- E. Comply with NFPA 70.
- F. Comply with NFPA 110.
- G. Comply with UL 1008 unless requirements of these Specifications are stricter.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Contactor Transfer Switches:
 - a. Caterpillar; Engine Div.
 - b. Emerson; ASCO Power Technologies, LP.
 - c. Onan/Cummins Power Generation; Industrial Business Group.
 - d. Thomson Power Systems.
 - e. Approved equal.

2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

- A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.
- B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
- C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.
- D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
- E. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.
- F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
 - 1. Switch Action: Double throw; mechanically held in both directions.

2. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.
- G. Neutral Terminal: Solid and fully rated, unless otherwise indicated.
- H. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Section 26 05 00 – General Requirements for Electrical Work.
- I. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, unless otherwise indicated/required.

2.3 AUTOMATIC TRANSFER SWITCHES

- A. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.
- B. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.
- C. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.
- D. Automatic Transfer-Switch Features:
 1. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
 2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
 3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
 4. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.

5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
 - a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
 - b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."
8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
 - a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
 - b. Push-button programming control with digital display of settings.
 - c. Integral battery operation of time switch when normal control power is not available.

2.4 SOURCE QUALITY CONTROL

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

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details.
- B. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

3.2 CONNECTIONS

- A. Ground equipment according to Section 26 05 26 – Grounding and Bonding for Electrical systems.
- B. Connect wiring according to Section 26 05 19 – Conductors and Communications Cabling.

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- B. Perform tests and inspections and prepare test reports.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installation, including connections, and to assist in testing.
 - 2. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
 - 3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
 - a. Check for electrical continuity of circuits and for short circuits.
 - b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
 - c. Verify that manual transfer warnings are properly placed.
 - d. Perform manual transfer operation.
 - 5. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.

- a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
 - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
 - c. Verify time-delay settings.
 - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
 - e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
 - f. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
- C. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- D. Remove and replace malfunctioning units and retest as specified above.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below.

END OF SECTION 26 36 00

SECTION 26 37 00 – GENERATOR TAP BOX

PART 1 - GENERAL

1.1 SUMMARY

- A. This specification defines the requirements for Generator Tap Boxes.
- B. The purpose of the Generator Tap Box is to provide an easy means to quickly connect a temporary generator to the electrical system due to utility failure or to facilitate maintenance on upstream electrical equipment.
- C. The Generator Tap Box shall be installed on the building exterior and be hardwired to the main switchboard, motor control center or transfer switch, as indicated on the plans.

1.2 SUBMITTALS

- A. Furnish in accordance with Contract Documents.
- B. The following information shall be submitted to the engineer:
 - 1. Top, bottom and elevation views
 - 2. Schematic diagram
 - 3. Conduit entry/exit locations
 - 4. Assembly and component ratings including: Short-circuit rating, Voltage, Continuous current, Interrupting ratings
 - 5. Cable terminal sizes
 - 6. Product data sheets

1.3 QUALITY

- A. Generator Tap Boxes be completely assembled by a certified ISO facility.
- B. Generator Tap Boxes shall be completely assembled and undergo a functional test procedure prior to shipment. This test shall be documented and included with the Generator Tap Box.
- C. All Generator Tap Boxes shall be built in accordance with the National Electric Code.
- D. Product shall be listed and tested by an OSHA accredited NRTL (Nationally Recognized Test Lab) to UL Standard

1.4 WARRANTY

- A. Vendor shall warrant the products manufactured and delivered to be free from defects in material and workmanship for a period of twelve (12) months after date of shipment.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All components shall be new and free of defects.

2.2 MANUFACTURERS

- A. Manufacturers complying with the Quality Assurance requirements are acceptable.
 - 1. Eaton – Specify on drawings to match existing sites
 - 2. Approved equal

2.3 ELECTRICAL RATINGS

- A. Generator Tap Boxes shall be rated for single phase 100-240VAC and three phase 208-600VAC.
- B. Generator Tap Boxes shall be available in an ampacity range of 400-4000A.
- C. Generator Tap Boxes shall be available in both three and four wire configurations.

2.4 ENCLOSURE

- A. Enclosure shall be NEMA Type 3R, wall-mount with welded mounting tabs or free-standing with mounting feet.
- B. Enclosure material shall be galvanized steel with RAL7035 light-gray finish or Type 316 stainless-steel.
- C. Enclosure shall have both a hinged front access door with padlockable wing knob latch, and hinged bottom access door for cable entry.

2.5 CAM-PLATES

- A. Cam-plates shall be ten-gauge galvanized steel with RAL7035 light-gray finish or Type 316 stainless-steel.
- B. Cam-plates shall be interchangeable with hole-cutouts for E1016 Cam-Lok receptacles.
- C. For single phase or three-wire applications, a blank cam-plate shall be installed in the empty cutout.

2.6 CAM-LOK RECEPTACLES

- A. Cam-Lok receptacles shall be insulated single pole, Cooper E1016 series, male with a single hole busbar connection.

B. Cam-Lok receptacles shall be color coded for each phase depending upon system voltage.

1. Phase Conductors

- a. 208-240VAC-Black, Red, Blue
- b. 480VAC-Brown, Orange, Yellow
- c. Neutral Conductor-White
- d. Ground Conductor-Green

C. Ground Cam-Lok receptacles shall be bonded to the enclosure.

2.7 BUSBAR

A. Busbar shall be tin-plated copper with mounting holes for mechanical lugs or bolt holes for compression lugs.

B. Busbar shall be sized at 1000A/sq. in.

2.8 LUGS

A. Lugs for permanent conductors shall be aluminum, dual rated, with a mechanical screw.

B. Lugs shall accept a wire-range of (1) #2-750 MCM.

2.9 ACCESSORIES

A. Label equipment with applicable rotation needed.

- 1. This site uses a L rotation

PART 3 - EXECUTION

3.1 INSTALLATION

A. The Generator Tap Box shall be installed correctly according to the provided manual and in an appropriate location.

B. Wall-mounted Generator Tap Boxes shall be installed on a building exterior or equivalent.

C. Free-standing Generator Tap Boxes shall be installed on a concrete pad.

D. Installation shall be in accordance with all applicable codes and standards.

3.2 CABLE-ENTRY

A. Enclosure penetrations for cable entry shall be used with appropriate components to maintain the NEMA 3R rating.

3.3 FIELD QUALITY CONTROL

- A. When the Generator Tap Box is properly installed and ready to accept a portable generator, the installer should follow operational instructions specified in the manual provided.

3.4 TRAINING

- A. The Contractor shall schedule and provide a training to the owner at the job site location.
- B. A manufacturer's qualified representative shall conduct the training session. The training program shall consist of instruction on operation of the assembly, including circuit breakers, fused switches, and major components within the assembly as required.

3.5 TESTING

- A. Check phase sequence and mark correct sequence on dead front panel.

END OF SECTION 26 37 00

SECTION 26 43 13 – TRANSIENT-VOLTAGE SUPPRESSION FOR LOW-VOLTAGE ELECTRICAL
POWER CIRCUITS

PART 1 - GENERAL

1.1 SCOPE

- A. The Contractor shall furnish and install the Surge Protective Device (SPD) equipment having the electrical characteristics, ratings, and modifications as specified herein and as shown on the contract drawings. To maximize performance and reliability and to obtain the lowest possible let-through voltages, the ac surge protection shall be integrated into electrical distribution equipment such as switchgear, switchboards, panelboards, busway (integrated within bus plug), or motor control centers (MCC). Refer to related sections for surge requirements in:

1.2 REFERENCES

- A. SPD units and all components shall be designed, manufactured, and tested in accordance with the latest applicable standards.
 - 1. ANSI/UL 1449 4th Edition or later
 - 2. ANSI/UL 1283 5th Edition or later (Type 2 applications)
 - 3. IEEE C62.41.1
 - 4. IEEE C62.41.2
 - 5. IEEE C62.43-2005
 - 6. IEEE C62.45-2002
 - 7. IEEE C62.48-2005
 - 8. IEEE C62.62-2010
 - 9. UL 96A
 - 10. NFPA 780
 - 11. FCC Part 15, Subpart B and ICES-003 – Radiated Emissions (for surge protection devices with communication capabilities)
 - 12. FCC Part 15, Subpart B and ICES-003 – Conducted Emissions (for surge protection devices with communication capabilities)

1.3 SUBMITTALS – FOR REVIEW/APPROVAL

- A. The following information shall be submitted to the Engineer:
 - 1. Provide verification that the SPD complies with the required ANSI/UL 1449 4th Edition or later listing by Underwriters Laboratories (UL). Compliance may be in the form of a file number that can be verified on UL's website www.ul.org, the website should contain the following information at a minimum: model number, SPD Type, system voltage, phases, modes of protection, Voltage Protection Rating (VPR), Nominal Discharge Current In, and name of nationally recognized testing lab that performed the test.
- B. Where applicable the following additional information shall be submitted to the engineer:
 - 1. Descriptive bulletins
 - 2. Product sheets
- C. For side mount mounting applications (SPD mounted external to electrical assembly), electrical/mechanical drawings showing unit dimensions, weights, installation instruction details, and wiring configuration.

1.4 SUBMITTALS – FOR CONSTRUCTION

- A. The following information shall be submitted for record purposes:
 - 1. Final as-built drawings and information for items listed in Section 1.04 and shall incorporate all changes made during the manufacturing process.

1.5 QUALIFICATIONS

- A. The manufacturer of the electrical distribution equipment shall be the manufacturer of the SPD within the listed electrical distribution equipment.
- B. For the equipment specified herein, the manufacturer shall be ISO 14001 and ISO 9001 or 9002 certified.
- C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of twenty-five (25) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
- D. The SPD shall be compliant with the Restriction of Hazardous Substances (RoHS) Directive 2011/65/EU and have a visible label showing compliance.
- E. The SPD shall be UL 1449 current edition listed, 20 kA In Type 1 or Type 2 for use in UL 96A systems.

1.6 DELIVERY, STORAGE AND HANDLING

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

1.7 OPERATION AND MAINTENANCE MANUALS

- A. Operation and maintenance manuals shall be provided with each SPD shipped.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly unless noted otherwise.
- B. The manufacturer shall be ISO 9001 or ISO 9002 certified for the equipment specified herein.
- C. The manufacturer shall have produced similar electrical equipment for a minimum period of five years.
- D. Eaton
 - 1. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features, and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the Engineer ten (10) days prior to bid date.

2.2 VOLTAGE SURGE SUPPRESSION – GENERAL

- A. Electrical Requirements
 - 1. Unit Operating Voltage – Refer to drawings for operating voltage and unit configuration.
 - 2. Maximum Continuous Operating Voltage (MCOV) – The MCOV shall not be less than 115% of the nominal system operating voltage.
 - 3. The suppression system shall incorporate thermally protected metal-oxide varistors (MOVs) as the core surge suppression component for the service entrance and all other distribution levels. The system shall not utilize silicon avalanche diodes, selenium cells, air gaps, or other components that may crowbar the system voltage leading to system upset or create any environmental hazards. End of life mode to be open circuit. Unit with end of life short-circuit mode are not acceptable.

4. Unit shall operate without the need for an external overcurrent protection device (OCPD) and be listed by UL as such. Unit must not require external OCPD or replaceable internal OCPD for the UL Listing.
5. Protection Modes – The SPD must protect all modes of the electrical system being utilized. The required protection modes are indicated by bullets in the following table:

Protection Modes				
Configuration	L-N	L-G	L-L	N-G
Wye	●	●	●	●
Delta	N/A	●	●	N/A
Single Split Phase	●	●	●	●
High Leg Delta	●	●	●	●

6. Nominal Discharge Current (In) – All SPDs applied to the distribution system shall have a 20kA In rating regardless of their SPD Type (includes Types 1 and 2) or operating voltage. SPDs having an In less than 20kA shall be rejected.
7. ANSI/UL 1449 4th Edition Voltage Protection Rating (VPR) – The maximum ANSI/UL 1449 4th Edition VPR for the device shall not exceed the following:

Modes	208Y/120	480Y/277	600Y/347
L-N; L-G; N-G	700	1200	1500
L-L	1200	2000	3000

B. SPD Design

1. Maintenance Free Design – The SPD shall be maintenance free and shall not require any user intervention throughout its life. SPDs containing items such as replaceable single-mode modules, replaceable fuses, or replaceable batteries shall not be accepted. SPDs requiring any maintenance of any sort such as periodic tightening of connections shall not be accepted. SPDs requiring user intervention to test the unit via a diagnostic test kit or similar device shall not be accepted.
2. Balanced Suppression Platform – The surge current shall be equally distributed to all MOV components to ensure equal stressing and maximum performance. The surge suppression platform must provide equal impedance paths to each matched MOV. Designs incorporating replaceable SPD modules shall not be accepted.
3. Electrical Noise Filter – Each Type 2 unit shall include a high-performance EMI/RFI noise rejection filter. Noise attenuation for electric line noise shall be up to 50 dB from 10 kHz to 100 MHz using the MIL-STD-220A insertion loss test method. Products unable able to meet this specification shall not be accepted.
4. Type 2 units with filtering shall conform to UL 1283 5th Edition.
5. Type 1 units shall not contain filtering or have a UL 1283 5th Edition Listing.

6. Internal Connections – No plug-in component modules or printed circuit boards shall be used as surge current conductors. All internal components shall be soldered, hardwired with connections utilizing low impedance conductors.
7. Monitoring Diagnostics – Each SPD shall provide the following integral monitoring options:
 - a. Protection Status Indicators - Each unit shall have a green / red solid-state indicator light that reports the status of the protection on each phase.
 - 1) For wye configured units, the indicator lights must report the status of all protection elements and circuitry in the L-N and L-G modes. Wye configured units shall also contain an additional green / red solid-state indicator light that reports the status of the protection elements and circuitry in the N-G mode. SPDs that indicate only the status of the L-N and L-G modes shall not be accepted.
 - 2) For delta configured units, the indicator lights must report the status of all protection elements and circuitry in the L-G and L-L modes
 - 3) The absence of a green light and the presence of a red light shall indicate that damage has occurred on the respective phase or mode. All protection status indicators must indicate the actual status of the protection on each phase or mode. If power is removed from any one phase, the indicator lights must continue to indicate the status of the protection on all other phases and protection modes. Diagnostics packages that simply indicate whether power is present on a particular phase shall not be accepted.
 - b. Remote Status Monitor (optional) – The SPD must include Form C dry contacts (one NO and one NC) for remote annunciation of its status. Both the NO and NC contacts shall change state under any fault condition.
 - c. Audible Alarm and Silence Button (optional) – The SPD shall contain an audible alarm that will be activated under any fault condition. There shall also be an audible alarm silence button used to silence the audible alarm after it has been activated.

- d. Surge Counter (optional) – The SPD shall be equipped with an LCD display that indicates to the user how many surges have occurred at the location. The surge counter shall trigger each time a surge event with a peak current magnitude of a minimum of $50 \pm 20A$ occurs. A reset pushbutton shall also be standard, allowing the surge counter to be zeroed. The reset button shall contain a mechanism to prevent accidental resetting of the counter via a single, short-duration button press. In order to prevent accidental resetting, the surge counter reset button shall be depressed for a minimum of 2 seconds in order to clear the surge count total.
- 1) The ongoing surge count shall be stored in non-volatile memory. If power to the SPD is completely interrupted, the ongoing count indicated on the surge counter's display prior to the interruption shall be stored in non-volatile memory and displayed after power is restored. The surge counter's memory shall not require a backup battery in order to achieve this functionality.
- e. Advanced Monitoring Display (AMD) (optional) - The SPD shall be equipped with an LCD display that indicates to the user the quantity and magnitude of surges that have occurred on each phase.
- 1) AMD shall display remaining surge protection levels as a percentage with 0% = unprotected, 1-99% = partially protected, 100% = fully protected.
 - 2) In addition to the green/red monitoring solid-state indicator LED (reference 2.E.a) the LED shall include a yellow status to indicate the unit as partially protected
 - 3) AMD shall provide a surge counter for each phase with three categories as defined by IEEE standards (C62.41) as follows:
 - 4) Low Level surge (IEEE Category A)
 - 5) Medium Level surge (IEEE Category B)
 - 6) High Level surge (IEEE Category C)
 - 7) AMD shall provide local access to the following information and data: Surge counts for each phase and per category, total surge counts, event logs with time & date stamps (last 20 events of each category per phase), SPD Protection Level percentage, alarm status, device catalog number, style number, serial number, date code, firmware version, PCB serial number, device name, IP address, ethernet MAC address, and customer support contact information.
 - 8) User shall be capable of inputting the following info into the AMD: set date and time, set device name, change password, clear surge counts & event logs, edit MODBUS status, Edit IP Address, Edit Subnet Mask, and Edit Gateway.

- 9) User shall be capable of testing the display.
 - 10) The AMD option shall provide a RJ45 ethernet connection port on the surge device, which shall provide a means for secure firmware updates to the SPD.
 - 11) Time and date stamped events to be capable of being downloaded through a RJ45 ethernet connection port.
- f. Remote Monitoring (optional with AMD) – The SPD shall be capable of Ethernet communications via Modbus/TCP and BACnet protocols and contain an onboard webpage which complies with UL 2900 standards.
 - g. BACnet and Modbus/TCP shall be user configurable with access to the following registers:
 - h. Remaining surge protection levels as a percentage with 0% = unprotected, 1-99% = partially protected, 100% = fully protected
 - i. LED status for each indicator color (red/yellow/green)
 - j. Surge counter for each phase with three categories defined using the resultant current from IEEE waveforms (C62.41.2) as follows: Low Level surge (IEEE Category A), Medium Level surge (IEEE Category B), High Level surge (IEEE Category C)
 - k. Access to the following information and data: Surge counts for each phase and per category, total surge counts, event logs with time & date stamps (last 2000 low, 1500 medium, and 1000 high events on each phase), SPD Protection Level percentage, alarm status, device catalog number, style number, serial number, date code, firmware version, PCB serial number, device name, IP address, ethernet MAC address, and customer support contact information.
 - l. User shall be capable of remotely inputting the following information: set date and time, set device name, change password, clear surge counts & event logs, change sensitivity settings, edit MODBUS status, edit IP Address, edit Subnet Mask, and edit Gateway.
 - m. The onboard webpage shall provide a pre-configured user interface with access to the following information:
 - n. Remaining surge protection levels as a percentage with 0% = unprotected, 1-99% = partially protected, 100% = fully protected
 - o. LED status for each indicator color (red/yellow/green)
 - p. Surge counter for each phase with three categories defined using the resultant current from IEEE waveforms (C62.41.2) as follows: Low Level surge (IEEE Category A), Medium Level surge (IEEE Category B), High Level surge (IEEE Category C)

- q. Access to the following information and data: Surge counts for each phase and per category, total surge counts, event logs with time & date stamps (last 2000 low, 1500 medium, and 1000 high events on each phase), SPD Protection Level percentage, alarm status, device catalog number, style number, serial number, date code, firmware version, PCB serial number, device name, IP address, ethernet MAC address, and customer support contact information.
- r. User shall be capable of remotely inputting the following information: set date and time, set device name, change password, clear surge counts & event logs, edit MODBUS status, edit IP Address, edit Subnet Mask, and edit Gateway.

C. Thermal MOV Protection

- 1. The unit shall contain thermally protected MOVs. These self-protected MOVs shall have a thermal protection element integrated with the MOV and a mechanical disconnect with arc quenching capabilities in order to achieve overcurrent protection of the MOV. The thermal protection assembly shall disconnect the MOV(s) from the system in a fail-safe manner should a condition occur, that would cause them to enter a thermal runaway condition.
- 2. Fully Integrated Component Design – All of the SPD's components and diagnostics shall be contained within one discrete assembly. The use of plug in single-mode modules that must be ganged together in order to achieve higher surge current ratings or other functionality shall not be accepted.

D. Safety Requirements

- 1. The SPD shall minimize potential arc flash hazards by containing no single-mode plug in user serviceable / replaceable parts and shall not require periodic maintenance. SPDs containing items such as replaceable single-mode plug in modules, replaceable fuses, or replaceable batteries shall not be accepted. SPDs requiring any maintenance of any sort such as periodic tightening of connections shall not be accepted. SPDs requiring user intervention to test the unit via a diagnostic test kit or similar device shall not be accepted.
- 2. SPDs designed to interface with the electrical assembly via conductors shall require no user contact with the inside of the unit. Such units shall have any required conductors be factory installed.
- 3. Side mount SPD's shall be factory sealed in order to prevent access to the inside of the unit with factory installed phase, neutral, ground and remote alarm contacts shall have conductors protruding outside of the enclosure for field wiring.

2.3 SYSTEM APPLICATION

- A. The SPD applications covered under this section include distribution and branch panel locations, busway, motor control centers (MCC), switchgear, and switchboard assemblies. All SPDs shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category C, B, and A environments.
- B. Surge Current Capacity – The minimum surge current capacity the device is capable of withstanding shall be as shown in the following table:

Minimum surge current capacity based on ANSI / IEEE C62.41 location category			
Category	Application	Per Phase	Per Mode
C	Service Entrance Locations (Switchboards, Switchgear, MCC, Main Entrance)	250 kA	125 kA
B	High Exposure Roof Top Locations (Distribution Panelboards)	160 kA	80 kA
A	Branch Locations (Panelboards, MCCs, Busway)	120 kA	60 kA

- C. Verify SPD’s are compatible with active harmonic filters.

2.4 LIGHTING AND DISTRIBUTION PANELBOARD REQUIREMENTS

- A. The SPD application covered under this section includes lighting and distribution panelboards. The SPD units shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category B environments.
 - 1. The SPD shall not limit the use of through-feed lugs, sub-feed lugs, and sub-feed breaker options.
 - 2. SPDs shall be installed immediately following the load side of the main breaker. SPDs installed in main lug only panelboards shall be installed immediately following the incoming main lugs.
 - 3. The panelboard shall be capable of re-energizing upon removal of the SPD.
 - 4. The SPD shall be integral to the panelboard and connected directly to the bus. Alternately, an integral SPD can be connected to a circuit breaker for disconnecting purposes, in the case a disconnect is required.
 - 5. The SPD shall be included and mounted within the panelboard by the manufacturer of the panelboard.
 - 6. The SPD shall be of the same manufacturer as the panelboard.
 - 7. The complete panelboard including the SPD shall be UL67 listed.

2.5 SWITCHGEAR, SWITCHBOARD, MCC AND BUSWAY REQUIREMENTS

- A. The SPD application covered under this section is for switchgear, switchboard, MCC, and busway locations. Service entrance located SPDs shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category C environments.
- B. The SPD shall be of the same manufacturer as the switchgear, switchboard, MCC, or busway.
- C. The SPD shall be factory installed integral to the switchgear, switchboard, MCC, and/or bus plug at the assembly plant by the original equipment manufacturer. Location of SPD shall be such that it does not require de-energization of switchgear, switchboard, MCC or panelboard for replacement.
- D. Locate the SPD on the load side of the main disconnect device, as close as possible to the phase conductors and the ground/neutral bar.
- E. The SPD shall be connected through a disconnect (30A circuit breaker). The disconnect shall be located in immediate proximity to the SPD. Connection shall be made via bus, conductors, or other connections originating in the SPD and shall be kept as short as possible.
- F. The SPD shall be integral to switchgear, switchboard, MCC, and/or bus plug as a factory standardized design.
- G. All monitoring and diagnostic features shall be visible from the front of the equipment.

2.6 SERVICE ENTRANCE REQUIREMENTS

- A. Service entrance located SPDs shall be tested and designed for applications within ANSI/IEEE C62.41 Category C environments.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Host equipment Manufacturer's representative shall visit the site, verify installation and testing, and verify that the SPD equipment and SPD installation meets intent of the Contract Documents and manufacturer's warranties and that the guarantees are in effect.

3.2 FACTORY TESTING

- A. Standard factory tests shall be performed on the equipment under this section. All tests shall be in accordance with the latest version of NEMA, IEEE, and UL standards.

3.3 INSTALLATION

- A. The installation of the SPD shall be factory installed integral to the distribution equipment. The Contractor shall install all distribution equipment per the manufacturer's recommendations, applicable electrical codes, and the contract drawings. Electrical equipment manufacturer shall authorize and perform bus taps connections, as necessary.

3.4 WARRANTY

- A. The manufacturer shall provide a ten (10) year warranty (15 year warranty with registration) that covers replacement of the complete unit, including lightning, from the date of shipment against any SPD part failure when installed in compliance with manufacturer's written instructions and any applicable national or local electrical code.

END OF SECTION 26 43 13

SECTION 26 51 00 - INTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Contract Documents including drawings and general provisions of the Contract, including General and Supplementary Conditions and specification sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes interior lighting fixtures, lighting fixtures mounted on exterior building surfaces, LED light engines, LED drives, emergency lighting units, and accessories.

1.3 SUBMITTALS

- A. Product Data: For each type of lighting fixture indicated, arranged in order of fixture designation. Include data on features, accessories, and the following:
 - 1. Dimensions of fixtures.
 - 2. LED drivers.
 - 3. LED light engine.
- B. Shop Drawings: Show details of nonstandard or custom fixtures. Indicate dimensions, weights, method of field assembly, components, features, and accessories.
 - 1. Wiring Diagrams: Detail wiring for fixtures and differentiate between manufacturer-installed and field-installed wiring.
- C. Product Certificates: Signed by manufacturers of lighting fixtures certifying that products comply with requirements.
- D. Dimming Ballast Compatibility Certificates: Signed by manufacturer of ballast certifying that ballasts are compatible with dimming systems and equipment with which they are used.
- E. Maintenance Data: For lighting fixtures to include in maintenance manuals specified in Contract Documents.

1.4 QUALITY ASSURANCE

- A. Fixtures, Emergency Lighting Units, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.
- B. Comply with NFPA 70.
- C. NFPA 101 Compliance: Comply with visibility and luminance requirements for exit signs.

1.5 COORDINATION

- A. Fixtures, Mounting Hardware, and Trim: Coordinate layout and installation of lighting fixtures with ceiling system and other construction.

1.6 WARRANTY

- A. General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.
- B. Special Warranty for Batteries: Written warranty, executed by manufacturer agreeing to replace rechargeable batteries that fail in materials or workmanship within specified warranty period. Contractor to include written warranty in final O&M manual.
 - 1. Special Warranty Period for Batteries: Manufacturer's standard, but not less than 5 years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for last nine years.
- C. Special Warranties for LED Drivers: Written warranty, executed by manufacturer agreeing to replace LED drivers that fail in materials or workmanship within specified warranty period. Contractor to include written warranty in final O&M manual.
 - 1. Special Warranty Period for LED Drivers: Five years form date of manufacture, but not less than four years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Products: Subject to compliance with requirements, provide one of the products indicated for each designation:
 - 1. Light Fixtures: As indicated on Drawing fixture schedule.
 - 2. LED Drivers: Compatible with LED light engine.
 - 3. LED Light Engine: Per manufacturer on Drawing fixture schedule.

2.2 FIXTURES AND FIXTURE COMPONENTS, GENERAL

- A. Metal Parts: Free from burrs, sharp corners, and edges.
- B. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.
- C. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during maintenance and when secured in operating position.

- D. Reflecting Surfaces: Minimum reflectance as follows, unless otherwise indicated:
 - 1. White Surfaces: 85 percent.
 - 2. Specular Surfaces: 83 percent.
 - 3. Diffusing Specular Surfaces: 75 percent.
 - 4. Laminated Silver Metallized Film: 90 percent.
- E. Lenses, Diffusers, Covers, and Globes: 100 percent virgin acrylic plastic or annealed crystal glass, unless otherwise indicated.
 - 1. Plastic: High resistance to yellowing and other changes due to aging, exposure to heat, and ultraviolet radiation.
 - 2. Lens Thickness: 0.125-inch minimum, unless greater thickness is indicated.

2.3 LED DRIVERS

- A. General Requirements: Unless otherwise indicated, features include the following:
 - 1. Shall be electronic-type, labeled as compliant with radio frequency interference (RFI) requirements of FCC Title 47, Part 15.
 - 2. Total Harmonic Distortion Rating: Less than 20 percent at all input voltages.
 - 3. Sound Rating: A.
 - 4. Minimum efficiency of 85%.
- B. LED Drivers: Unless otherwise indicated, features include the following, besides those in "General Requirements" Paragraph above:
 - 1. Dimmable drivers shall be 0-10V type.
 - 2. Dimmable drivers shall be capable of dimming without LED flicker or strobing across their full dimming range.
 - 3. Provide (3) spare LED drivers for each fixture type / Provide (3) Emergency drivers for each driver type.

2.4 EXIT SIGNS

- A. General Requirements: Comply with UL 924 and the following:
 - 1. Sign Colors and Lettering Size: Comply with authorities having jurisdiction.
- B. Self-illuminating exit sign: Brady part number 90887 or equal.
- C. Internally Lighted Signs: As follows:
 - 1. Lamps for AC Operation: Light-emitting diodes, 70,000 hours minimum rated lamp life.

2.5 EMERGENCY LED AND FLUORESCENT POWER SUPPLY UNITS

- A. Internal Type: Self-contained, modular, battery-inverter unit factory mounted within fixture body. Comply with UL 924.
 - 1. Test Switch and Light-Emitting Diode Indicator Light: Visible and accessible without opening fixture or entering ceiling space. Test switch shall illuminate LEDs or lamps for minimum of 3 minutes when pushed momentarily.
 - 2. Battery: Sealed, maintenance-free, nickel-cadmium type with minimum 5-year nominal life.
 - 3. Charger: Fully automatic, solid-state, constant-current type.
 - 4. Operation: Relay automatically energizes LEDs or lamp from unit when normal supply circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects LEDs or lamp, and battery is automatically recharged and floated on charger.
 - 5. Lumen output: Minimum 700 lumens (LED), Minimum 1350 lumens (T8 minimum lamps), Minimum 750 lumens (compact fluorescent 4-pin lamps).
- B. External Type: Self-contained, modular, battery-inverter unit. Comply with UL 924.
 - 1. Test Switch and Light-Emitting Diode Indicator Light: Visible and accessible without entering ceiling space. Test switch shall illuminate LEDs or lamps for minimum of 3 minutes when pushed momentarily.
 - 2. Battery: Sealed, maintenance-free, nickel-cadmium type with minimum 10-year nominal life.
 - 3. Charger: Fully automatic, solid-state, constant-current type.
 - 4. Operation: Relay automatically energizes LEDs or lamp from unit when normal supply circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects LEDs or lamp, and battery is automatically recharged and floated on charger.
 - 5. Housing: NEMA 250, Class 1 enclosure.
 - 6. Self-diagnostics.

2.6 LED LIGHT ENGINES

- A. LED Color Temperature: 5000 K, unless otherwise indicated.
- B. CCT tolerances are to be kept within a 3-step MacAdam ellipse and are to maintain a Min CRI of 80.

2.7 FIXTURE SUPPORT COMPONENTS

- A. Comply with Section 26 05 00 – General Requirements for Electrical Work for channel- and angle-iron supports, and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: ½ -inch steel tubing with swivel ball fitting and ceiling canopy. Finish same as fixture.
- C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy arranged to mount a single fixture. Finish same as fixture.
- D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.
- E. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.
- F. Aircraft Cable Support: Use cable, anchorages, and intermediate supports recommended by fixture manufacturer.

2.8 FINISHES

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

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Set units plumb, square, and level with ceiling and walls, and secure according to manufacturer's written instructions and approved Shop Drawings. Support fixtures according to requirements of Section 26 05 00 – General Requirements for Electrical Work.
- B. Support for Recessed and Semi-recessed Grid-type Fixtures:
 - 1. Pendant-hung lighting fixtures shall be supported directly from the structure above using No. 9-gauge wire or an approved alternate support without using the ceiling suspension system for direct support.
 - 2. Lighting fixtures weighing less than 56 pound shall have, in addition to the requirements outlined above, two No. 12 gauge hangers connected from the fixture housing to the structure above. These wires may be slack.
 - 3. Lighting fixtures weighing 56 pound or more shall be supported directly from the structure above by approved hangers.
- C. Support for Suspended Fixtures: Brace pendants and rods over 48 inches long to limit swinging. Support stem-mounted, single-unit, suspended fixtures with twin-stem hangers. For continuous rows, use unistrut to suspend several fixtures in a row.

- D. Surface-mounted lighting fixtures shall be attached to the ceiling system with positive clamping devices that completely surround the supporting members. Safety wires shall be attached between the clamping device and the adjacent ceiling hanger or to the structure above. In no case shall the fixture exceed the design carrying capacity of the supporting members.

3.2 CONNECTIONS

- A. Ground equipment.
 - 1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 467, UL 486A, and UL 486B.

3.3 FIELD QUALITY CONTROL

- A. Inspect each installed fixture for damage. Replace damaged fixtures and components.
- B. Tests: As follows:
 - 1. Verify normal operation of each fixture after installation.
 - 2. Emergency Lighting: Interrupt electrical supply to demonstrate proper operation.
 - 3. Verify normal transfer to battery source and retransfer to normal.
- C. Malfunctioning Fixtures and Components: Replace or repair, then retest. Repeat procedure until units operate properly.
- D. Corrosive Fixtures: Replace during warranty period.

3.4 CLEANING AND ADJUSTING

- A. Clean fixtures internally and externally after installation. Use methods and materials recommended by manufacturer.
- B. Adjust amiable fixtures to provide required light intensities.

3.5 SPARE PARTS

- A. Three spare LED drivers for each fixture type, including emergency fixture drivers.

END OF SECTION 26 51 00

SECTION 26 56 00 - EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Contract Documents including drawings and general provisions of the Contract, including General and Supplementary Conditions and specification sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes exterior lighting fixtures, lamps, ballasts, poles standards, and accessories.

1.3 SUBMITTALS

- A. General: Submit the following according to Contract Documents.
- B. Product data describing fixtures, lamps, ballasts, poles, and accessories. Arrange product data for fixtures in order of fixture designation. Include data on features, poles, accessories, and the following:
 - 1. Outline Drawings of fixtures and poles indicating dimensions and principal features.
 - 2. Electrical ratings and photometric data with certified results of laboratory tests.
- C. Maintenance data for materials and products, in accordance with Contract Documents and Section 26 05 00 – General Requirements for Electrical Work. Include service bulletin(s).
 - 1. Submit maintenance data and parts list for each roadway and parking area lighting fixture and accessory; including "trouble-shooting" maintenance guide. Include that data, product data, service bulletin(s), and illustrated parts list in a maintenance manual; in accordance with requirements of Contract Documents.

1.4 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of exterior lighting units, 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: Firms with at least 3 years of successful installation experience on projects with exterior lighting installation work similar to that required for this Project.

PART 2 - PRODUCTS

2.1 FIXTURE COMPONENTS, GENERAL

- A. Metal Parts: Free from burrs and sharp edges and corners.

- B. Sheet Metal Components: Corrosion-resistant aluminum, except as indicated. Form and support to prevent warping and sagging.
- C. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed fixtures.
- D. Doors, Frames, and Other Internal Access Provisions: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in the operating position. Provide for door removal for cleaning or replacing lens. Arrange for door opening to disconnect ballast.
- E. Exposed Hardware Material: Stainless steel.
- F. Reflecting Surfaces: Minimum reflectances as follows, except as otherwise indicated:
 - 1. White Surfaces: 85 percent.
 - 2. Specular Surfaces: 83 percent.
 - 3. Diffusing Specular Surfaces: 75 percent.
- G. Plastic Parts: Resistant to yellowing and other changes due to aging and exposure to heat and UV radiation.
- H. Lenses and Refractors: Materials as indicated. Use heat-and aging-resistant, resilient gaskets to seal and cushion lens and refractor mounting in fixture doors.
- I. Photoelectric Relay: UL 773.
 - 1. Contact Relays: Single-throw, arranged to fail in the "on" position and factory set to turn light unit on at 1.5 to 3 footcandles and off at 4.5 to 10 footcandles with 15 seconds' minimum time delay.
 - 2. Relay Mounting: In fixture housing.

2.2 FIXTURE SUPPORT COMPONENTS

- A. Mountings, Fastenings, and Appurtenances: Provide mountings that will correctly position the luminaire to provide the indicated light distribution.

2.3 LAMPS

- A. Conform to ANSI Standards, C78 series, applicable to each type of lamp. Provide fixtures with indicated lamps. Where lamps are not indicated, provide lamps recommended by manufacturer.

2.4 FINISH

- A. Metal Parts: Manufacturer's standard finish except as otherwise indicated. Finish applied over corrosion-resistant primer after fabrication, free of streaks, runs, holidays, stains, blisters, and similar defects. Remove poles, fixtures, and accessories showing evidence of corrosion or finish failure during Project warranty period and replace with new items.
- B. Other Parts: Manufacturer's standard finish except as otherwise indicated.
- C. Spare parts: Provide (3) LED drivers for each different fixture type. Provide (3) Emergency drivers for each fixture type containing an emergency driver.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Set units plumb, square, level, and secure according to manufacturer's written instructions and shop drawings.
- B. Fixture Attachment: Fasten to indicated structural supports.
- C. Fixture Attachment with Adjustable Features or Aiming: Attach fixtures and supports to allow aiming for indicated light distribution.
- D. Lamp fixtures with indicated lamps according to manufacturer's instructions. Replace malfunctioning lamps.
- E. Exterior lights are to be controlled by a single photocell located on North wall accessible with a six foot ladder. Provide and install a central lighting contactor with HOA switch located in electrical room.

3.2 FIELD QUALITY CONTROL

- A. Inspect installed units for damage.
- B. Provide advance notice of dates and times for field tests.
- C. Provide instruments to make and record test results.
- D. Tests: Verify normal operation of lighting units after installing fixtures and energizing circuits with normal power source. Include the following:
 - 1. Check for excessively noisy ballasts.
 - 2. Check for uniformity of illuminations.
- E. Replace or repair damaged and malfunctioning units and retest.

3.3 ADJUSTING AND CLEANING

- A. Clean components on completion of installation. Use methods and materials recommended by manufacturer.

B. Adjust aimable fixtures to provide required light intensities.

3.4 SPARE PARTS

A. Provide three spare LED drivers for each fixture type.

END OF SECTION 26 56 00

SECTION 40 41 00 - ELECTRIC HEAT TRACING SYSTEMS

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. This section includes electric heat tracing systems.

1.2 SUBMITTALS

- A. Shop Drawings: Provide shop drawings information in accordance with Contract Documents. Include performance data for all components of the heat tracing system.
- B. Operation and Maintenance Data:
 - 1. Provide operations and maintenance data per Contract Documents.

1.3 STANDARDS

- A. ANSI American National Standards Institute
- B. FM FM Approvals
- C. IEEE Institute Of Electrical and Electronics Engineers
- D. NEC U.S. National Electrical Code (NFPA 70)
- E. NEMA National Electrical Manufacturers Association
- F. UL Underwriters' Laboratories, Inc.

PART 2 - PRODUCTS

2.1 HEATING CABLES

- A. Heat-tracing applications in nonhazardous locations shall use self-regulating cables with a continuous maintain temperature of 150°F and an intermittent exposure temperature of 185°F. Heat-tracing applications in Division 1 hazardous locations shall use self-regulating cables with a continuous maintain temperature of 250°F and an intermittent exposure temperature of 420°F.
- B. Self-regulating heating cable shall vary its power output relative to the temperature of the surface of the pipe or valve. The cable shall be designed such that it can be crossed over itself and cut to length in the field.
- C. Self-regulating heating cable shall be designed for a useful life of 20 years or more with "power on" continuously, based on the following useful life criteria:

1. Retention of at least 75 percent of nominal rated power after 20 years of operation at the
 2. Maximum published continuous exposure temperature.
 3. Retention of at least 90 percent of nominal rated power after 1000 hours of operation at the maximum published intermittent exposure temperature. The testing shall conform to UL 746B, IEC 216-1 Part 1.
- D. A warranty against manufacturing defects for a period of 10 years shall be available.
- E. The heating cable shall consist of two 16 AWG or larger nickel-plated copper bus wires, embedded in a self-regulating polymeric core that controls power output so that the cable can be used directly on metallic pipes. Cables shall have a temperature identification number (T-rating) of T6 (185°F) without use of thermostats. Cables used in Division 1 hazardous locations shall have a T rating as required by FM hazardous location requirements.
- F. A ground-fault protection device set at 30A, with a nominal 100-ms response time, shall be used to protect each circuit.
- G. The heating cable shall have a tinned copper braid with a resistance less than the heating cable bus wire resistance as determined in type test (ASTM, B193, Sec. 5). The braid shall be protected from chemical attack and mechanical abuse by a fluoropolymer outer jacket.
- H. In order to provide rapid heat-up, to conserve energy, and to prevent overheating of fluids in the pipe, the heating cable shall have the following minimum self-regulating index:

Heating cable	S.R. index (W/°F)
5 W/ft	0.060
10 W/ft	0.100

1. The self-regulating index is the rate of change of power output in watts per degree Fahrenheit, as measured between the temperatures of 50°F and 100°F, and confirmed by the type test and published data sheets.
- I. In order to ensure that the self-regulating heating cable does not increase power output when accidentally exposed to high temperatures, resulting in thermal runaway and self-ignition, the cable shall produce less than 0.5 watts per foot when energized and heated to 350°F for 30 minutes. After this test, if the cable is re-energized, it must not have an increasing power output leading to thermal runaway.
- J. The self-regulating heating cable shall retain at least 90 percent of its original power output after having been cycled 300 times between 50°F and 210°F, allowing at least six minutes of dwell time at each temperature.
- K. Heat trace cable used in non-hazardous locations shall be Raychem® BTV self-regulating cable, Chromalox SRL self-regulating Cable, Tempco SL self-regulating cable, Thermon D1-HTSX self-regulating heating cable or equal.

2.2 THERMOSTATS

- A. Thermostats Controls shall energize the system when ambient air temperature drops below 40°F
- B. Thermostat enclosures for installation in non-hazardous locations shall be NEMA 4X.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Complete installation shall conform to appropriate local codes.
- B. Install cable heaters in accordance with detailed layout drawings and manufacturer's instructions.
- C. Band heating cable to pipe with tape wraps approximately every 12 inches. Only use fiberglass tape approved by the manufacturer of the heat tape for attaching the cable.
- D. Locate heating cable on pipe per manufacturer's instructions.
- E. Where heating cable is scheduled to heat plastic pipe, attach aluminum tape length of pipe and band heating cable on aluminum tape to evenly distribute heat.
- F. Self-Regulating (SR) Cable Installation
 - 1. Terminate non-power end of cable per termination kit instructions.
 - 2. Do not pinch or make sharp bends in cable.
 - 3. At power termination mount power connection standoff and junction box per power termination kit instructions. The electrical connection shall be made per the termination kit instruction and all local codes.
 - 4. All splice connections shall be made per the kit instruction and all local codes.
 - 5. Install a LED end of line indicator light on each heat trace circuit.
- G. Install labels on all heat trace cables, circuits, thermostats and boxes in accordance with specification section 26 05 00 - General Requirements for Electrical Work.

3.2 TESTING AND TRAINING

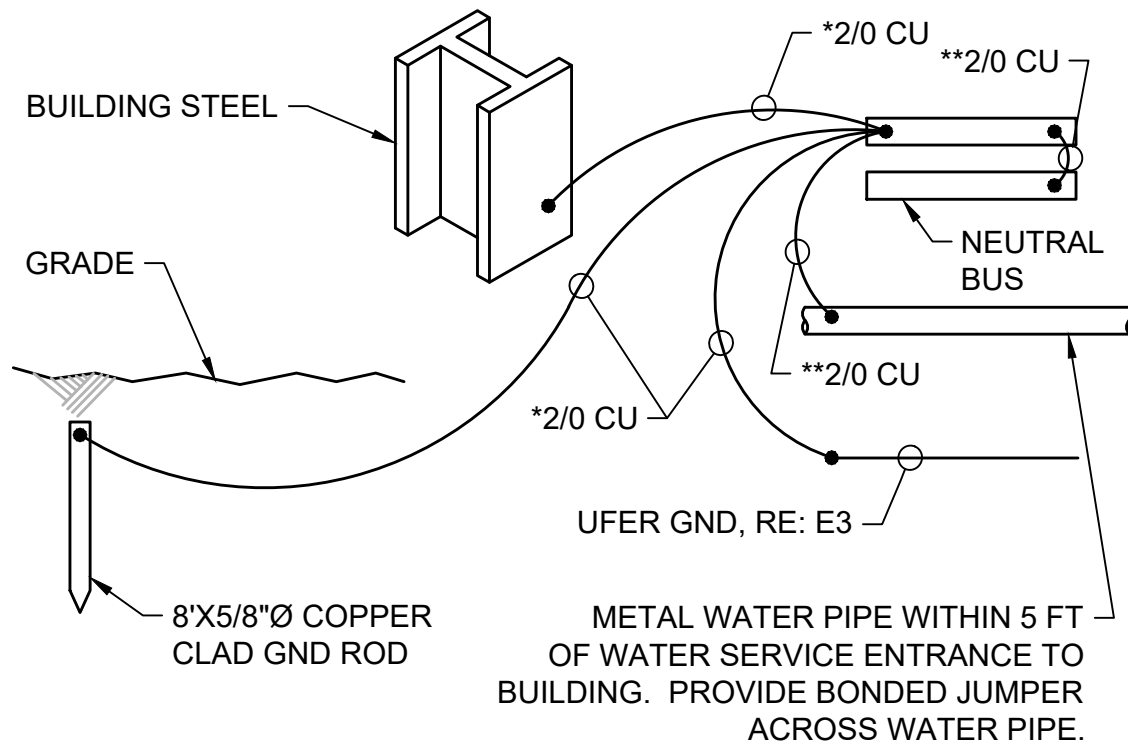
- A. Contractor shall test heat tracing system and certify that the installation is complete and operating per the Drawings and Specifications.
- B. Contractor shall provide training to the Owner's plant operator on the heat tracing system at each installation at the plant.

END OF SECTION 40 41 00

STANDARD DRAWINGS

NOTE:

1. CONNECTIONS SHALL BE FIRMLY BONDED TO NEUTRAL BUS, BUILDING STEEL, GROUNDING ROD AND WATER PIPE.
2. WIRE SIZES SHOWN ARE EXAMPLE. SIZES NEED TO BE REVIEWED AND COORDINATED WITH APPLICABLE CODES FOR EACH PROJECT.
3. USE ALL AVAILABLE GROUNDING ELECTRODES PER NEC.



*SIZE GROUNDING ELECTRODE ACCORDING TO NFPA 70 TABLE 250.66 (EXAMPLE SIZE SHOWN)

**BONDING JUMPERS TO BE SIZED ACCORDING TO NFPA 70 TABLE 250-102(C)

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CITY OF MERIDIAN
SUPPLEMENTAL
SPECIFICATIONS
TO THE IDAHO STANDARDS FOR
PUBLIC WORKS CONSTRUCTION

GROUNDING SYSTEM

STANDARD DRAWING NO.

E1

ELECTRICAL CONTRACTOR TO PROVIDE
"LIQUID TIGHT FLEXIBLE METALIC" CONDUIT TO
EQUIPMENT J-BOX & MAKE FINAL CONNECTION

PVC COATED RIGID COUPLING

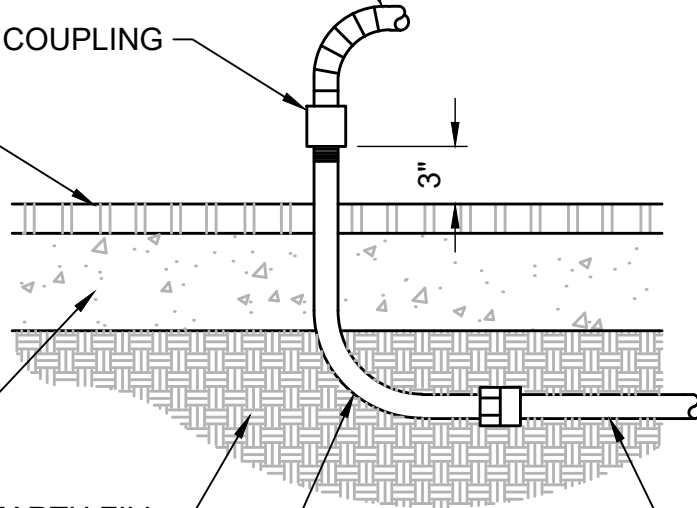
FLOOR FINISH
AS SPECIFIED

CONCRETE
SLAB

EARTH FILL

PVC COATED RIGID STEEL CONDUIT
ELBOW AND THROUGH THE SLAB.
SEE POWER PLAN FOR SIZES.

PVC SCH 40 CONDUIT.
SEE POWER PLAN
FOR SIZES



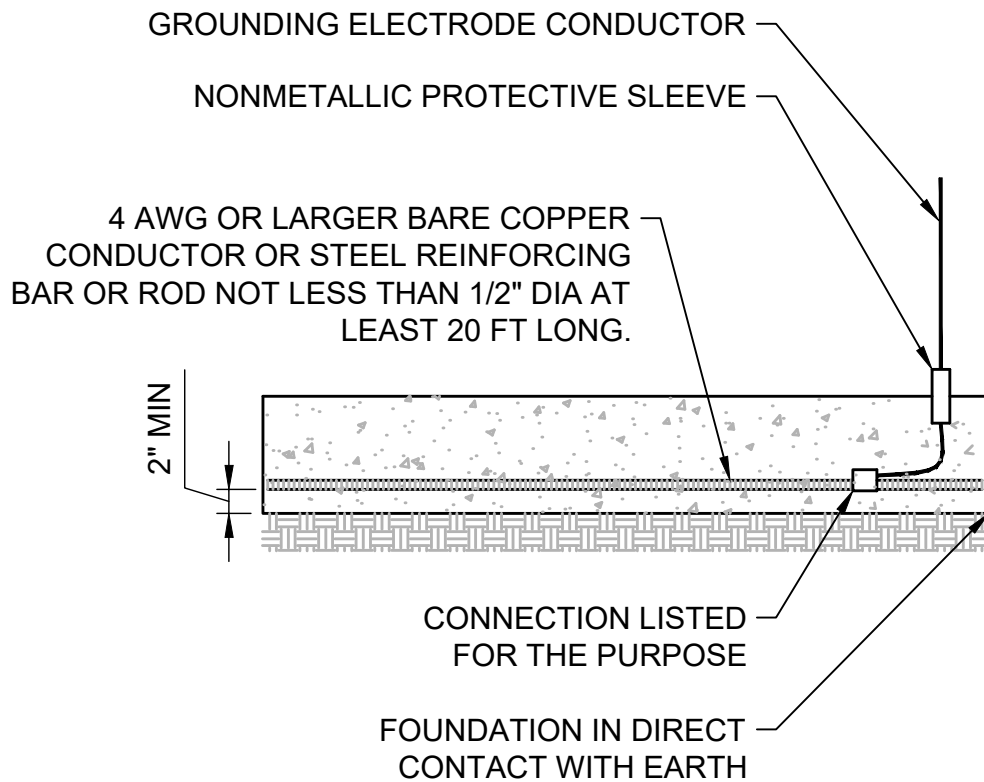
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CITY OF MERIDIAN
SUPPLEMENTAL
SPECIFICATIONS
TO THE IDAHO STANDARDS FOR
PUBLIC WORKS CONSTRUCTION

TYPICAL CONDUIT STUB-UP

STANDARD DRAWING NO.

E2



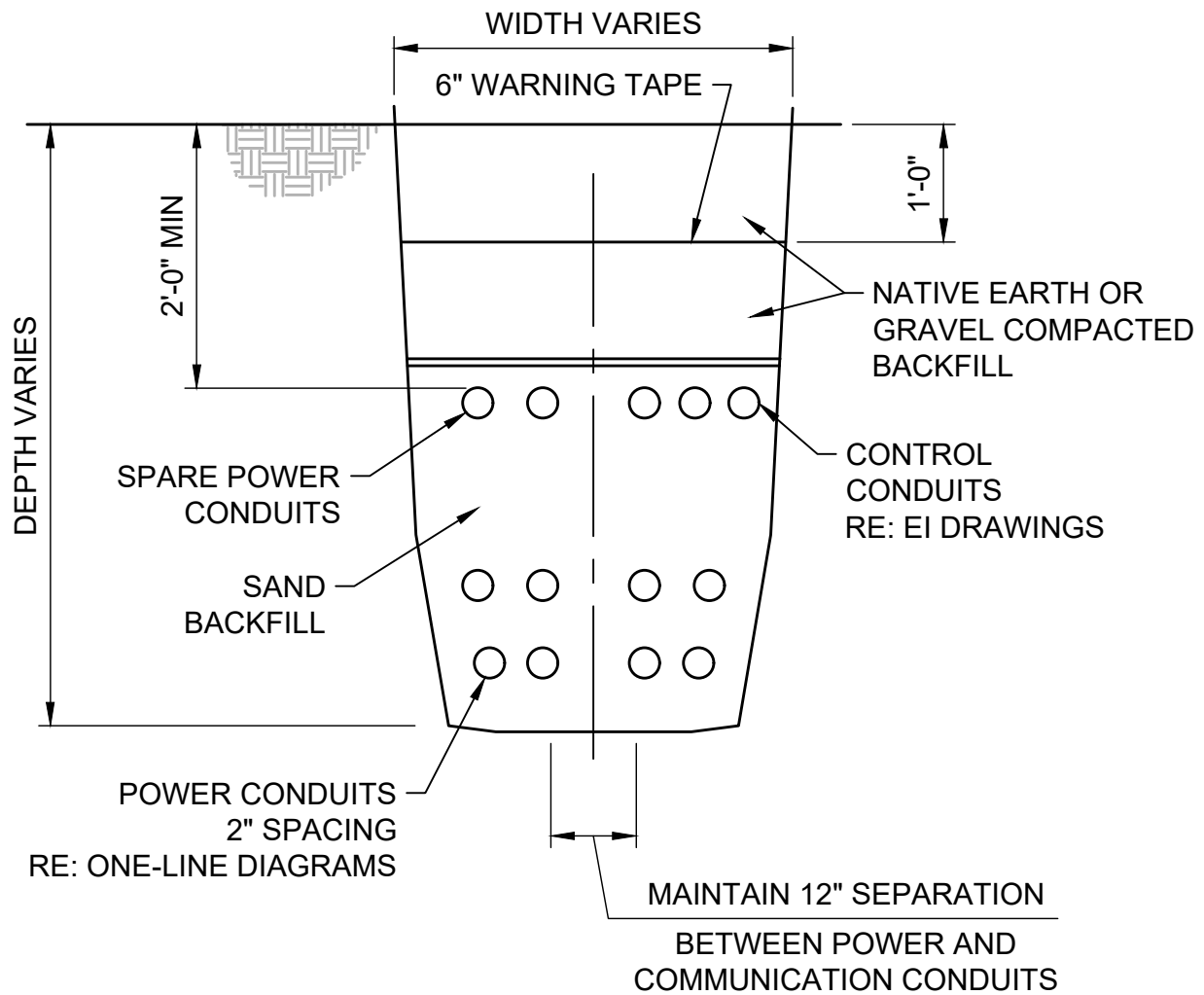
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CITY OF MERIDIAN
 SUPPLEMENTAL
 SPECIFICATIONS
 TO THE IDAHO STANDARDS FOR
 PUBLIC WORKS CONSTRUCTION

CONCRETE ENCASED
 ELECTRODE

STANDARD DRAWING NO.

E3



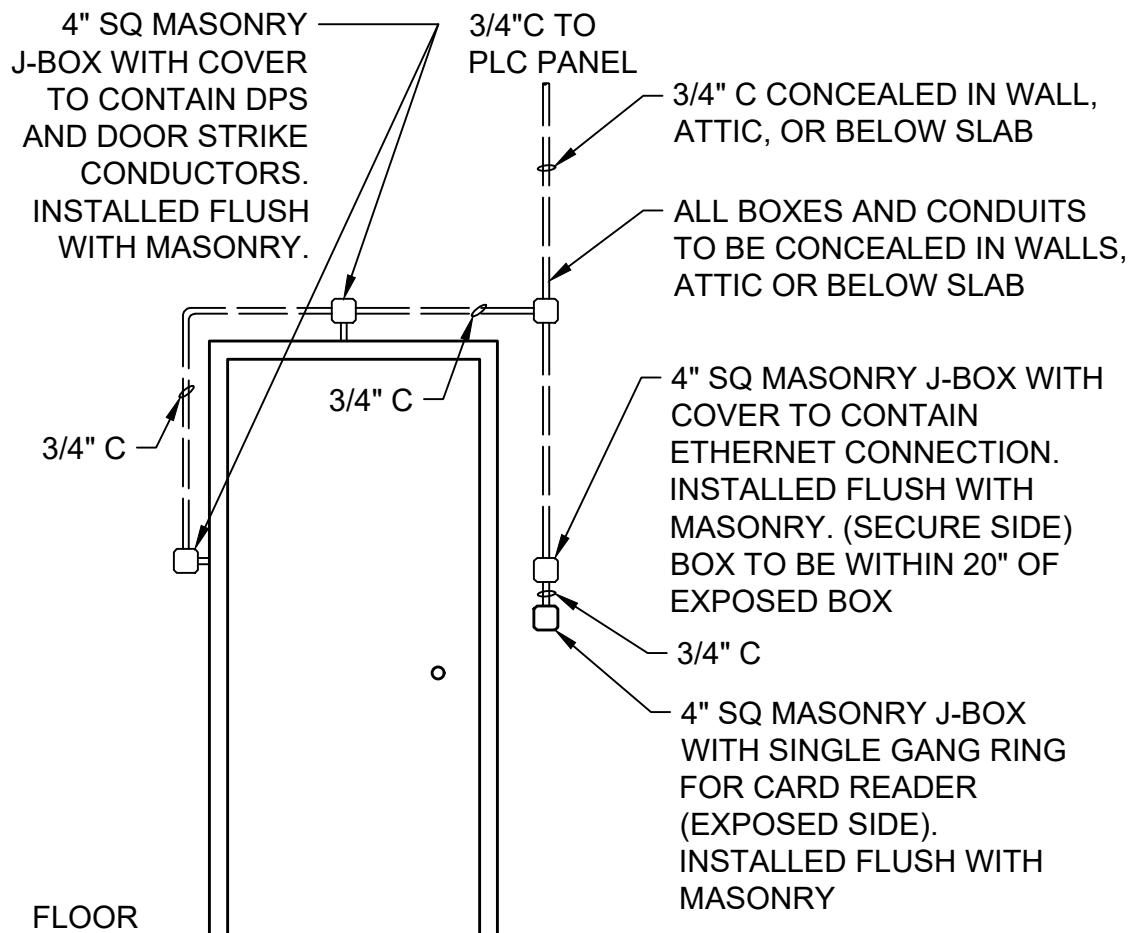
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CITY OF MERIDIAN
 SUPPLEMENTAL
 SPECIFICATIONS
 TO THE IDAHO STANDARDS FOR
 PUBLIC WORKS CONSTRUCTION

STANDARD ELECTRICAL DUCT BANK DETAIL

STANDARD DRAWING NO.

E4



* BOXES SHOULD BE MASONRY BOXES CONCEALED IN BLOCK TO ALLOW FLUSH INSTALL OF DEVICE(S).

*COORDINATE BOX LOCATIONS WITH DOOR HARDWARE SUPPLIER.

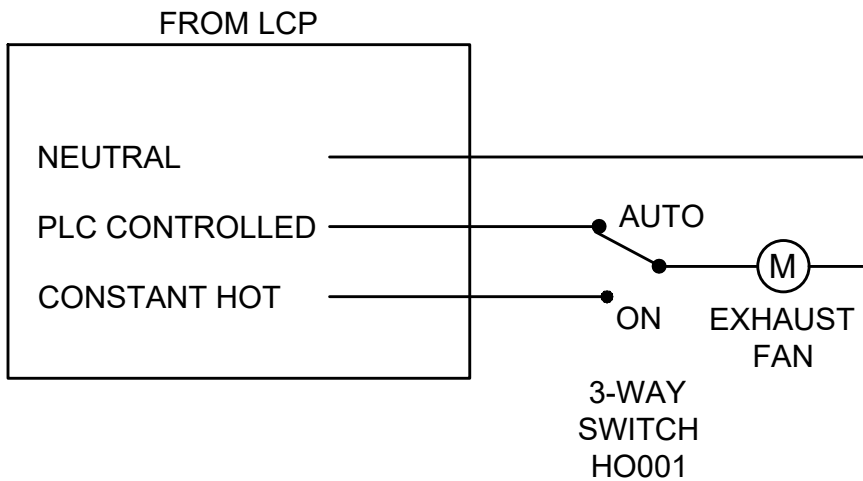
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CITY OF MERIDIAN
SUPPLEMENTAL
SPECIFICATIONS
TO THE IDAHO STANDARDS FOR
PUBLIC WORKS CONSTRUCTION

ACCESS CONTROL CONDUIT FOR CARD READER SYSTEM

STANDARD DRAWING NO.

E5



NOTE: WIRING DIAGRAM BASED ON 120V EQUIPMENT

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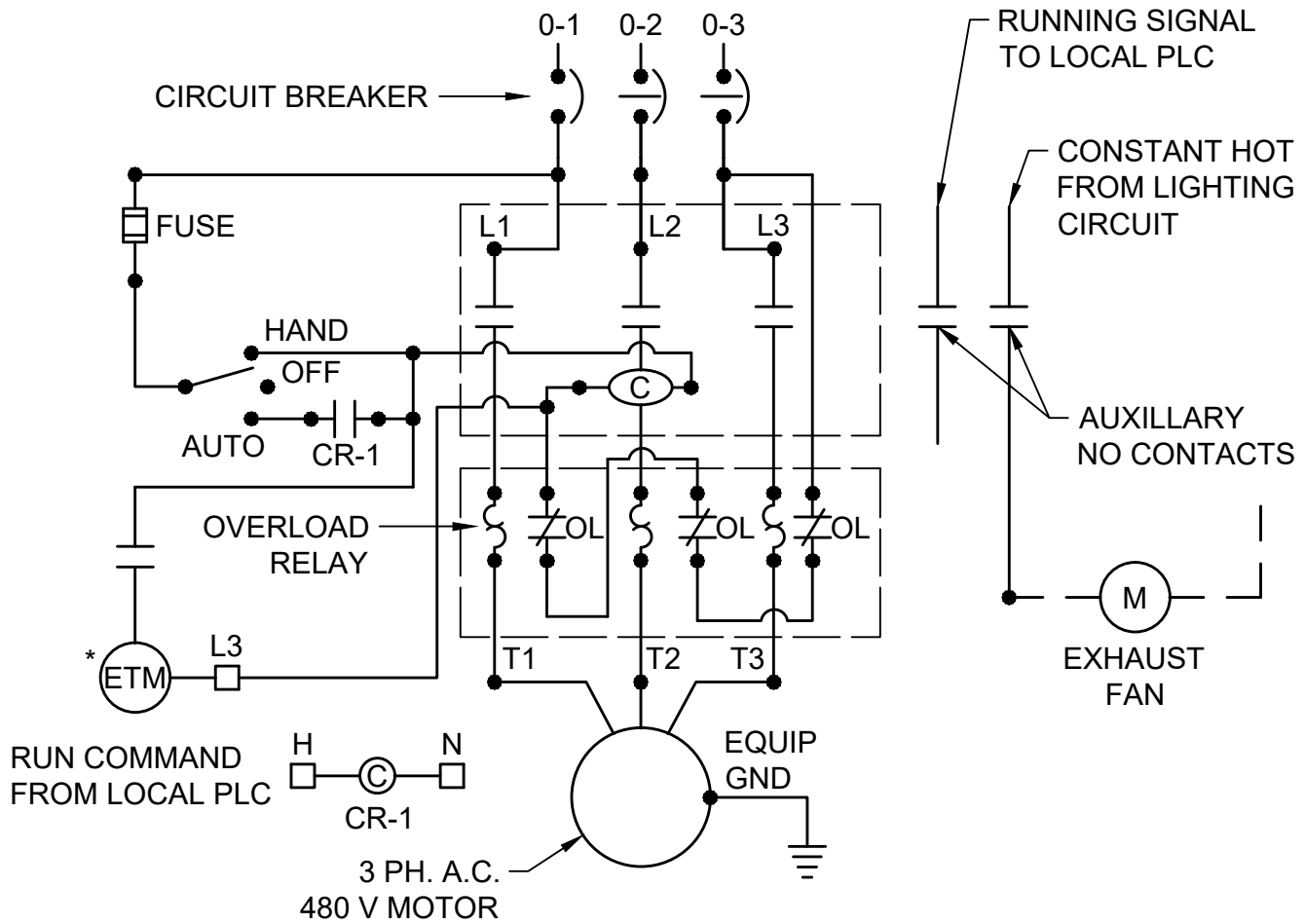
CITY OF MERIDIAN
SUPPLEMENTAL
SPECIFICATIONS
TO THE IDAHO STANDARDS FOR
PUBLIC WORKS CONSTRUCTION

CHEMICAL ROOM EXHAUST FAN
CONTROL DETAIL

STANDARD DRAWING NO.

E6

WIRING DIAGRAM



*ANALOG HOUR METER PER EQUIPMENT SPEC. POWERED VIA AUX. CONTACT

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CITY OF MERIDIAN
SUPPLEMENTAL
SPECIFICATIONS
TO THE IDAHO STANDARDS FOR
PUBLIC WORKS CONSTRUCTION

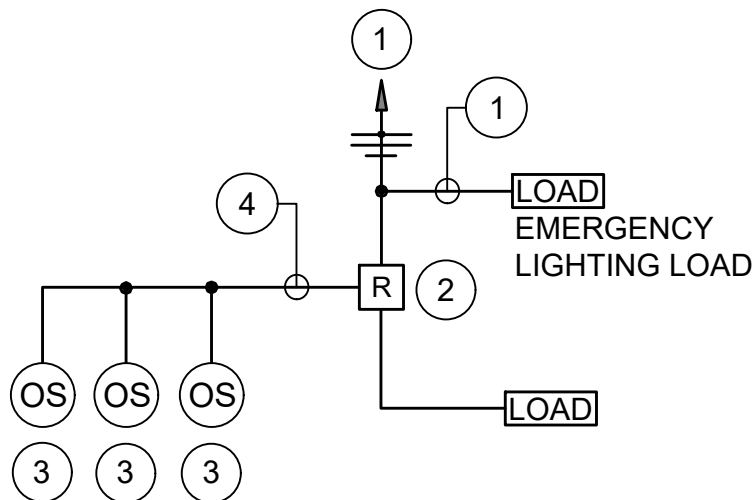
BLOWER AND EXHAUST FAN
CONTROL DETAIL

STANDARD DRAWING NO.

E7

DETAIL KEYED NOTES:

- ① SYMBOL USED FOR NOTE CALLOUT.
1. UNSWITCHED LINE VOLTAGE POWER FEED FROM LOCAL PANEL.
 2. POWER/RELAY PACK AS REQUIRED WITH LINE VOLTAGE SWITCHING. PROVIDE QUANTITY AS REQUIRED FOR A COMPLETE INSTALLATION.
 3. LOW VOLTAGE OCCUPANCY SENSOR. LOCATION PER THE MANUFACTURERS RECOMMENDATIONS.
 4. LOW VOLTAGE POWER AND CONTROL CONDUCTORS AS REQUIRED FOR A COMPLETE INSTALLATION.



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CITY OF MERIDIAN
SUPPLEMENTAL
SPECIFICATIONS
TO THE IDAHO STANDARDS FOR
PUBLIC WORKS CONSTRUCTION

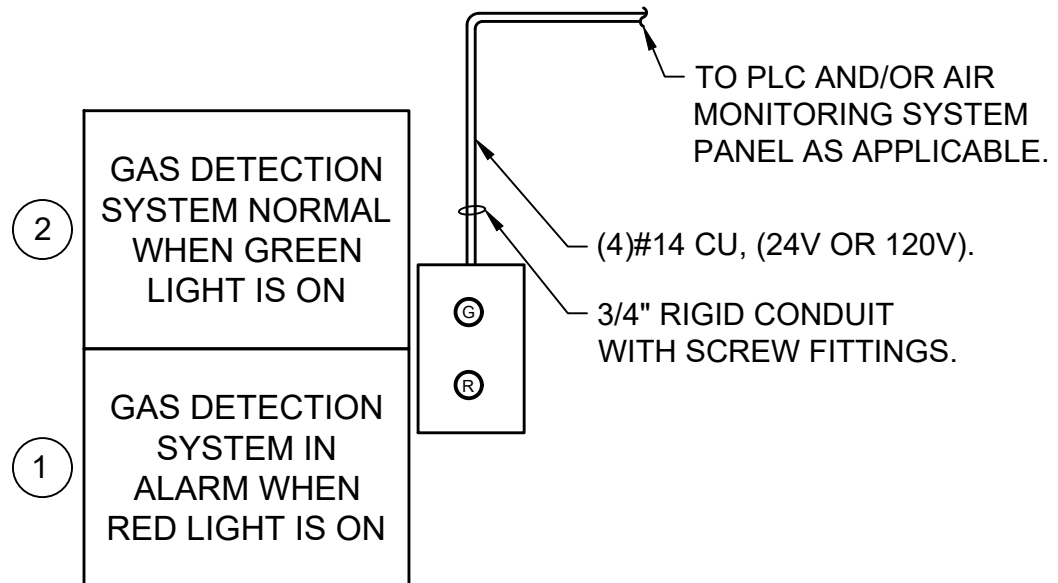
OCCUPANCY SENSOR DETAIL

STANDARD DRAWING NO.

E8

DETAIL KEYED NOTES:

- ① SYMBOL USED FOR NOTE CALLOUT.
1. SYSTEM IN ALARM WHEN RED LIGHT IS ON. (GAS DETECTED / VENTILATION SYSTEM FAILURE, HAZARDOUS, WARNING, DO NOT ENTER, VENTILATE)
 2. SYSTEM NORMAL WHEN GREEN LIGHT IS ON. (NO GAS DETECTED / VENTILATION SYSTEM OPERATIONAL, SAFE TO ENTER)



*REFERENCE NFPA 820 AREA CLASSIFICATION FOR MORE INFORMATION

FOR ADDITIONAL INFORMATION ON HAZARDOUS AREA ENTRY; REFERENCE SAFETY INSTRUCTIONS AS DEFINED IN THE OWNER'S SAFETY MANUAL.

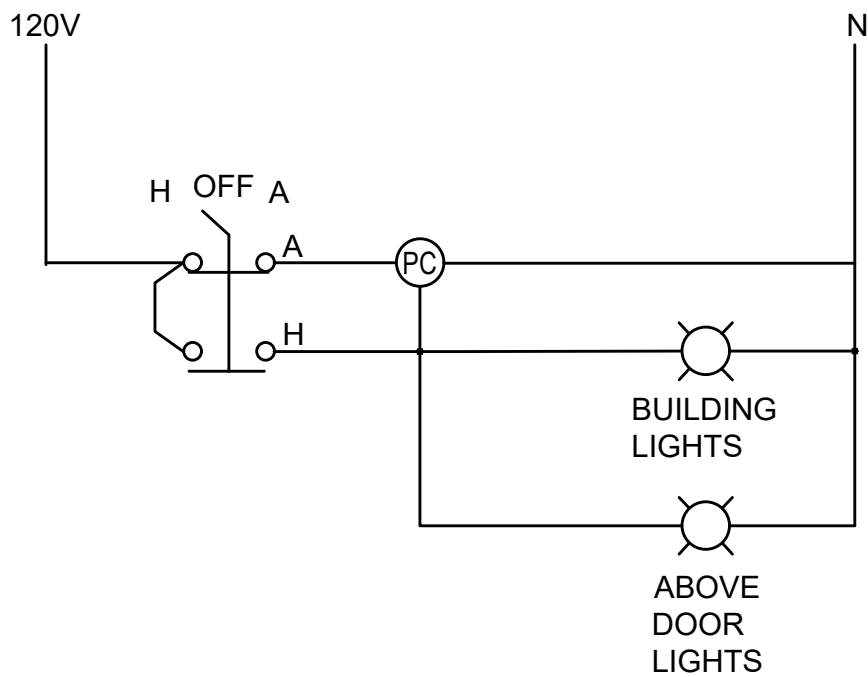
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CITY OF MERIDIAN
SUPPLEMENTAL
SPECIFICATIONS
TO THE IDAHO STANDARDS FOR
PUBLIC WORKS CONSTRUCTION

GO-NOGO INDICATOR EXAMPLE
FOR HAZARDOUS AREA ENTRY

STANDARD DRAWING NO.

E9



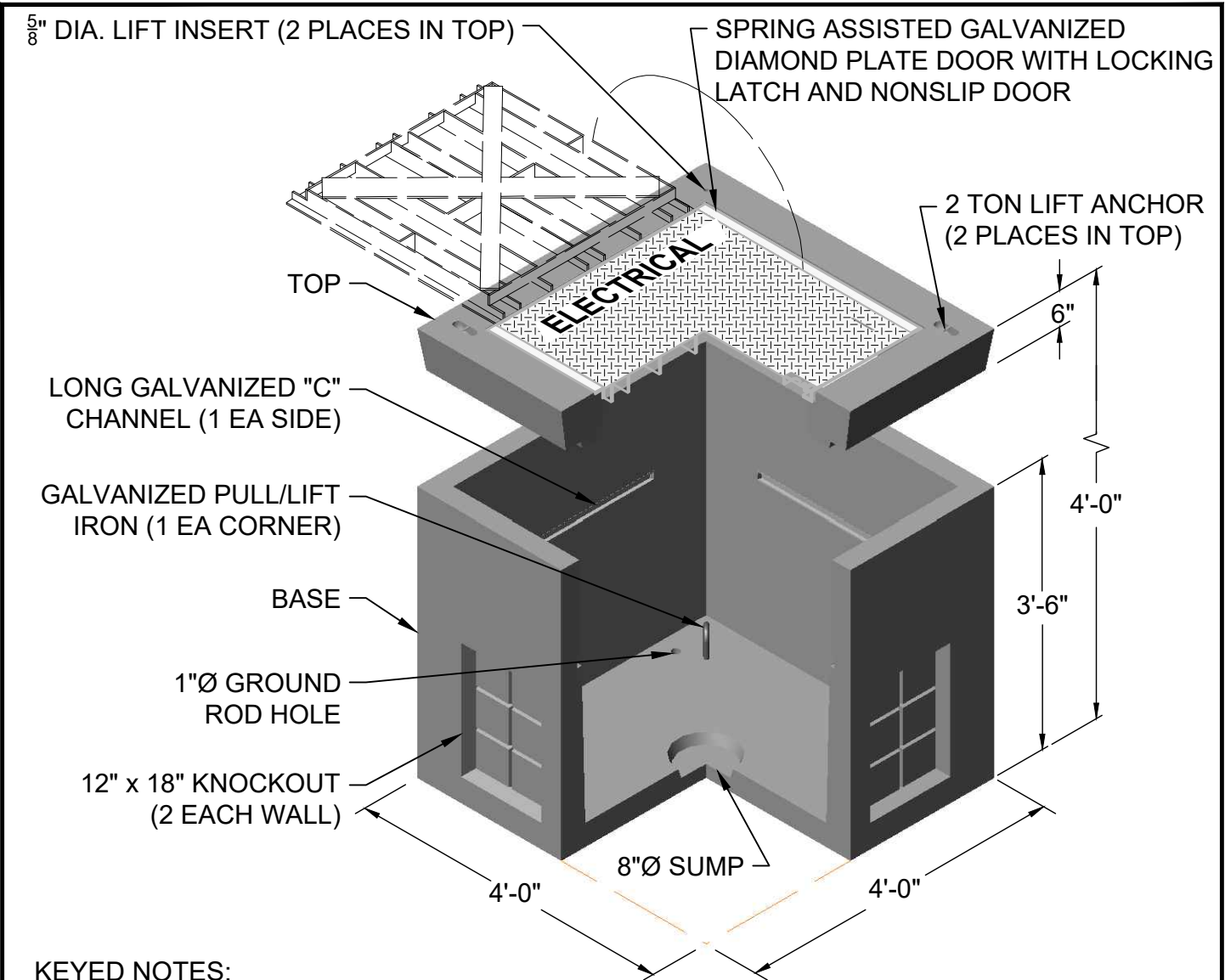
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CITY OF MERIDIAN
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 TO THE IDAHO STANDARDS FOR
 PUBLIC WORKS CONSTRUCTION

EXTERIOR LIGHTING CONTROL
 DETAIL

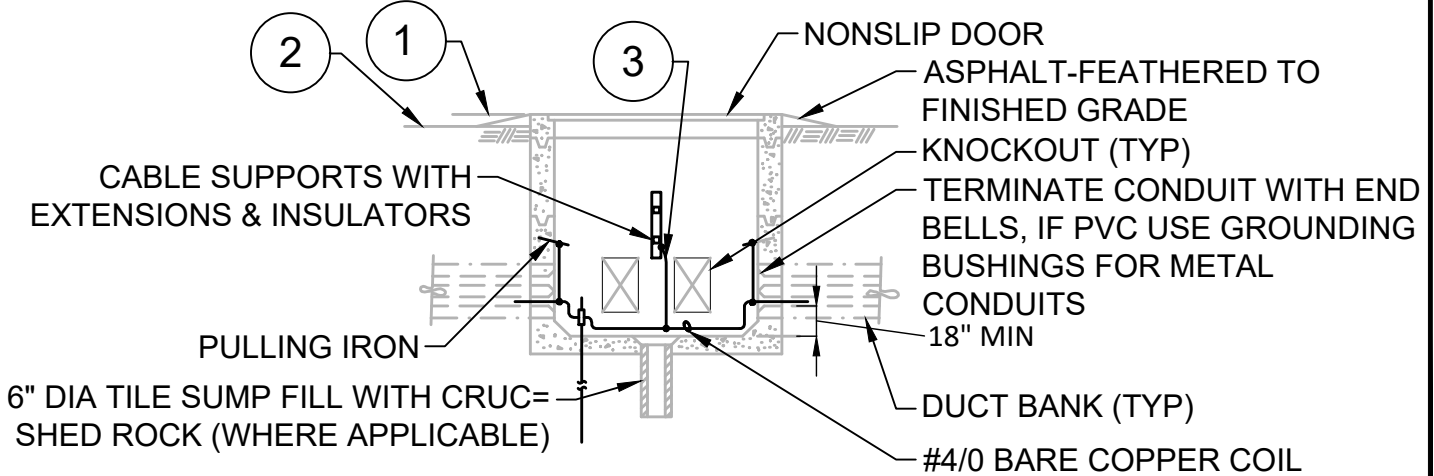
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E10



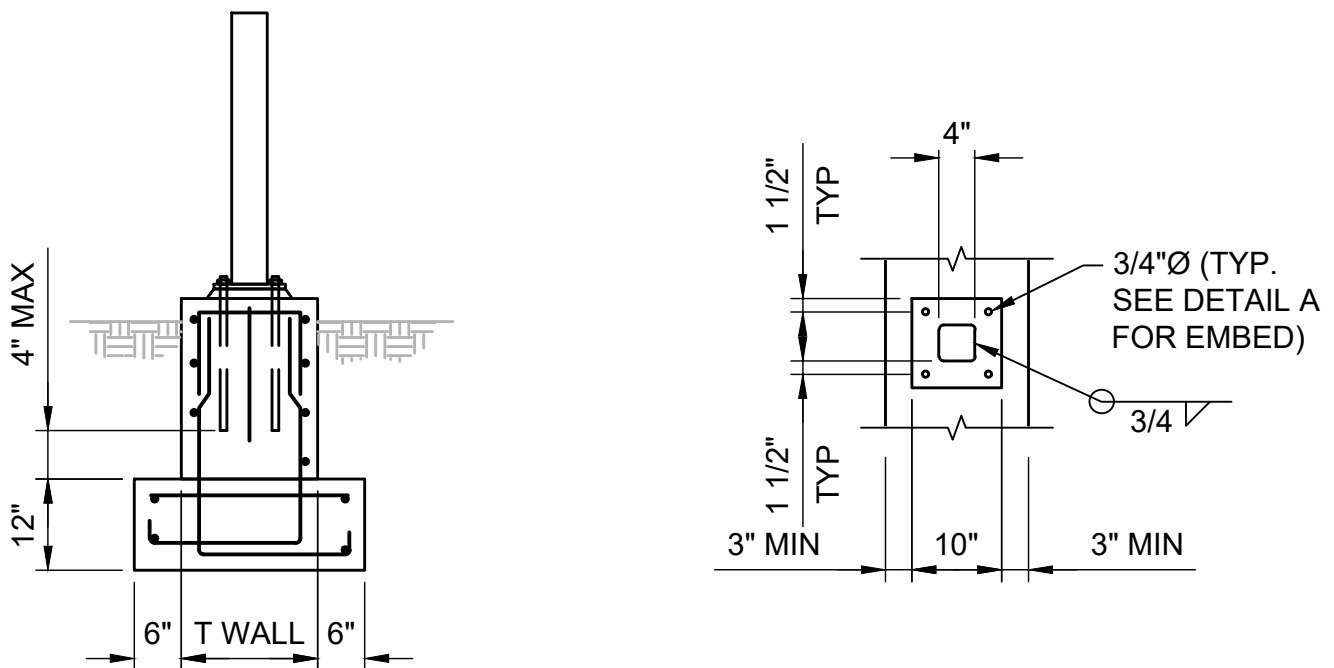
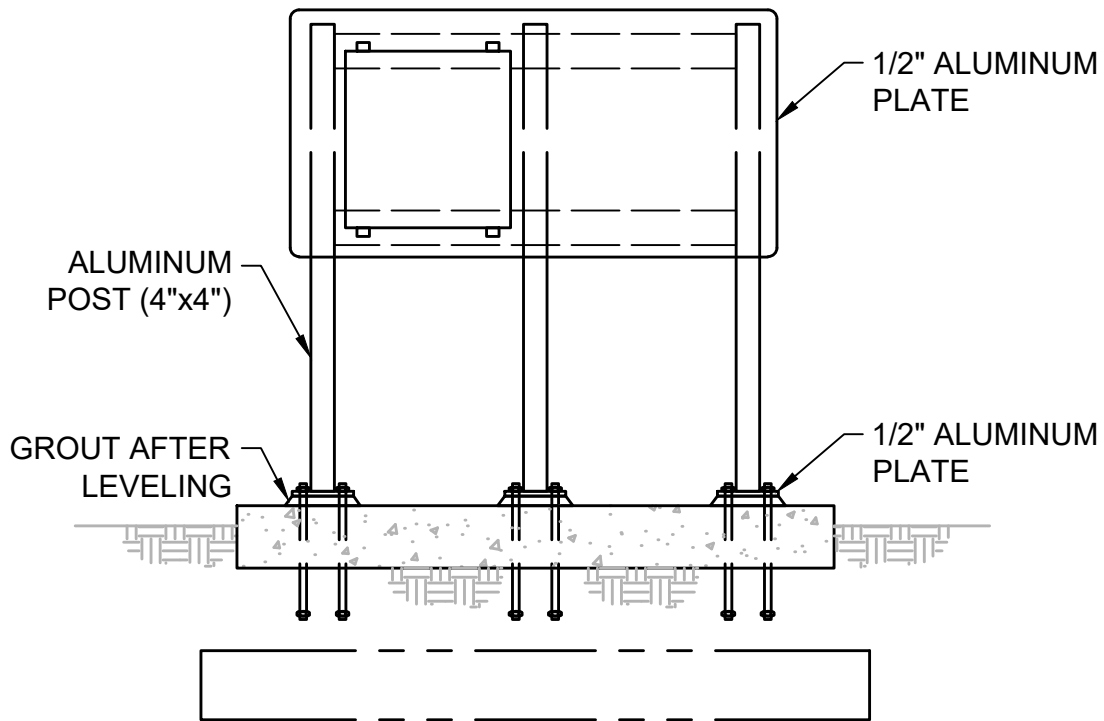
KEYED NOTES:

- 1. AT PAVED AREAS
- 2. AT UNPAVED AREAS
- 3. GROUND ALL METAL FRAMES AND SUPPORTS



NOTE: PULLBOX INSTALLATION TO BE WATERTIGHT AFTER CONDUITS HAVE BEEN INSTALLED.

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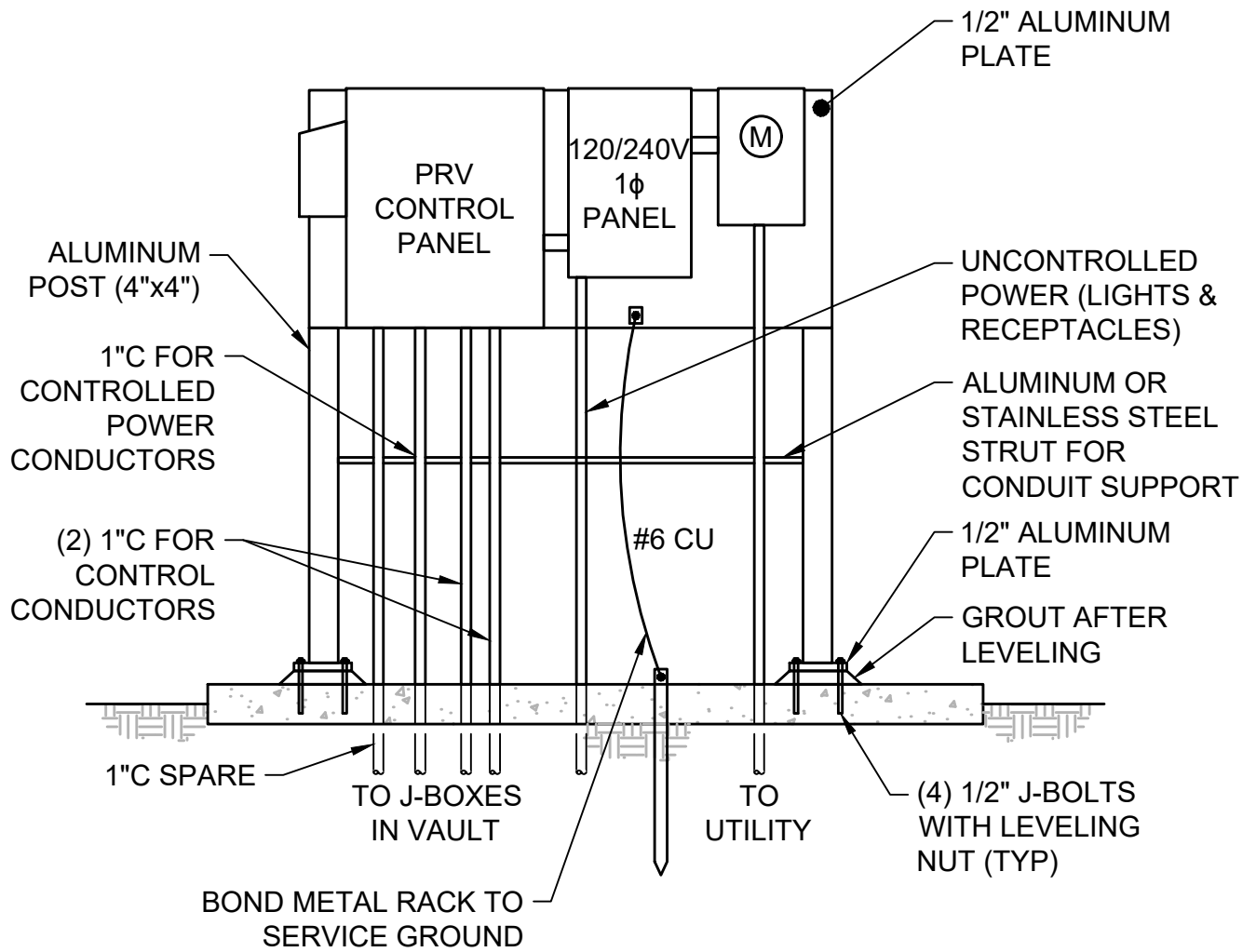
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CITY OF MERIDIAN
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 PUBLIC WORKS CONSTRUCTION

EQUIPMENT RACK DETAIL

STANDARD DRAWING NO.

E12



ELEVATION

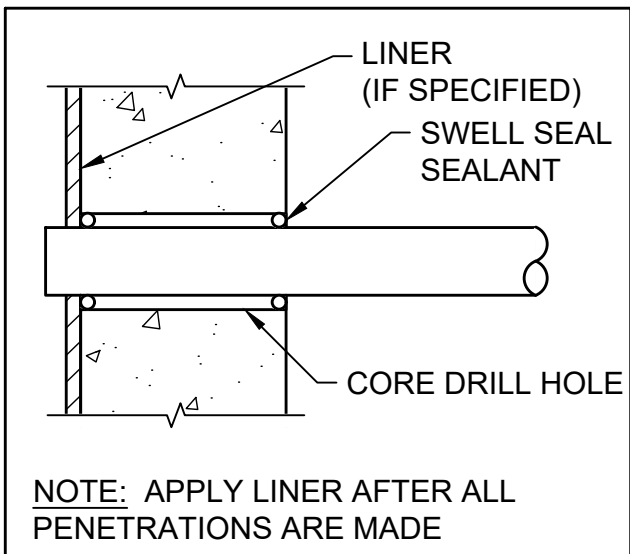
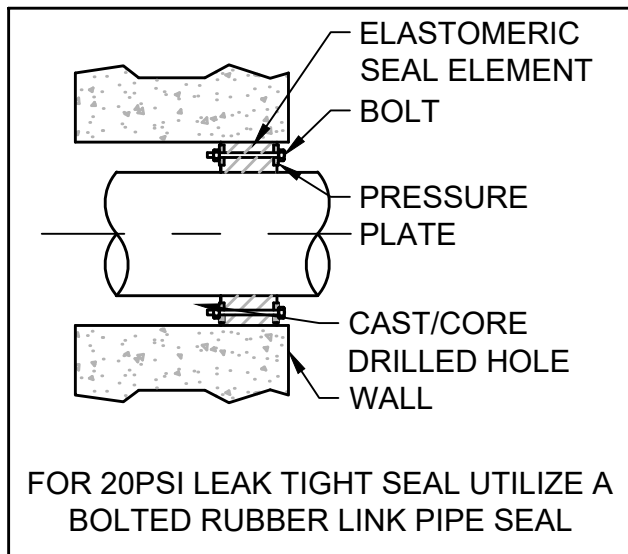
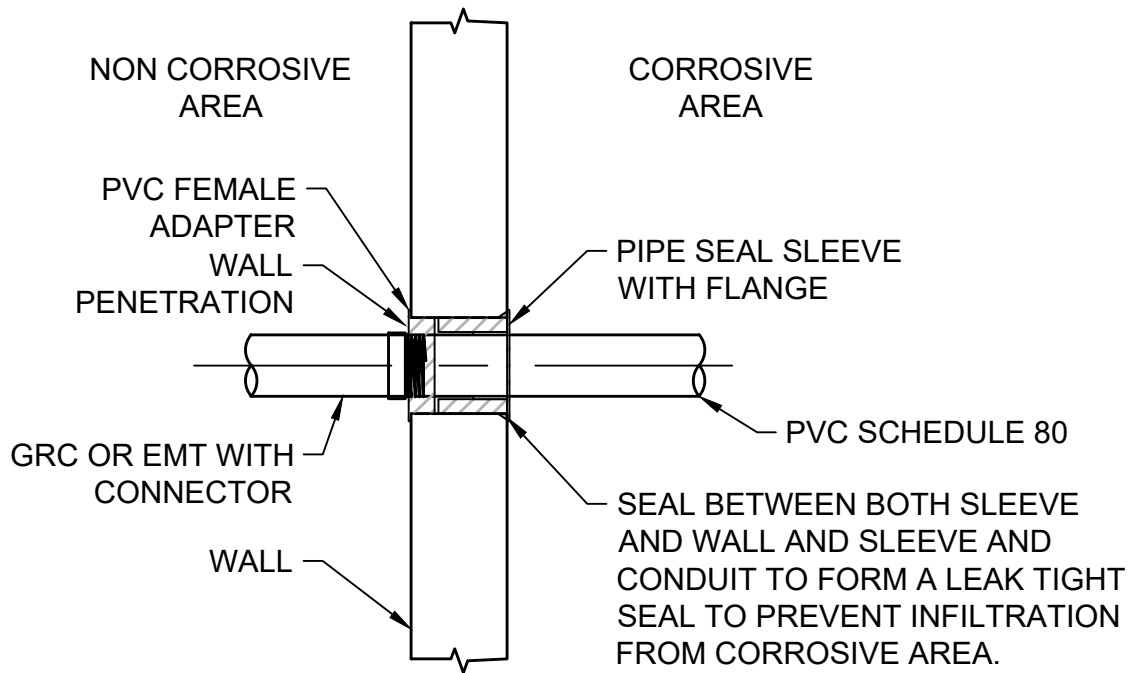
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CITY OF MERIDIAN
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 PUBLIC WORKS CONSTRUCTION

PRV RACK DETAIL

STANDARD DRAWING NO.

E13



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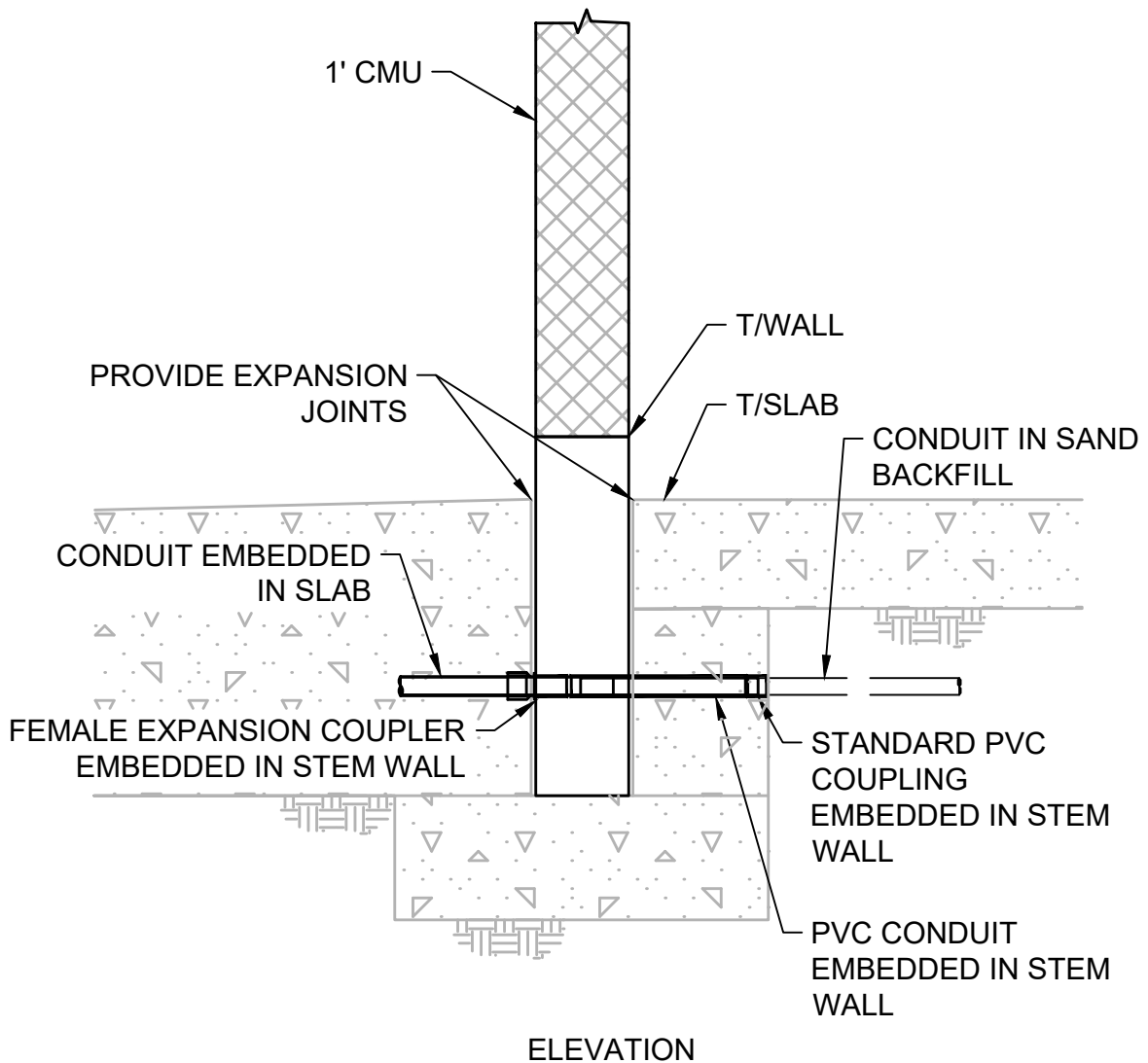
CORROSIVE AREA SEALING

STANDARD DRAWING NO.

E14

GENERAL NOTE:

THIS METHOD DELETES THE CONDUIT SLEEVE BUT STILL ALLOWS FOR LATERAL EXPANSION AND CONTRACTION BETWEEN THE STEM WALL AND 38" SLAB.



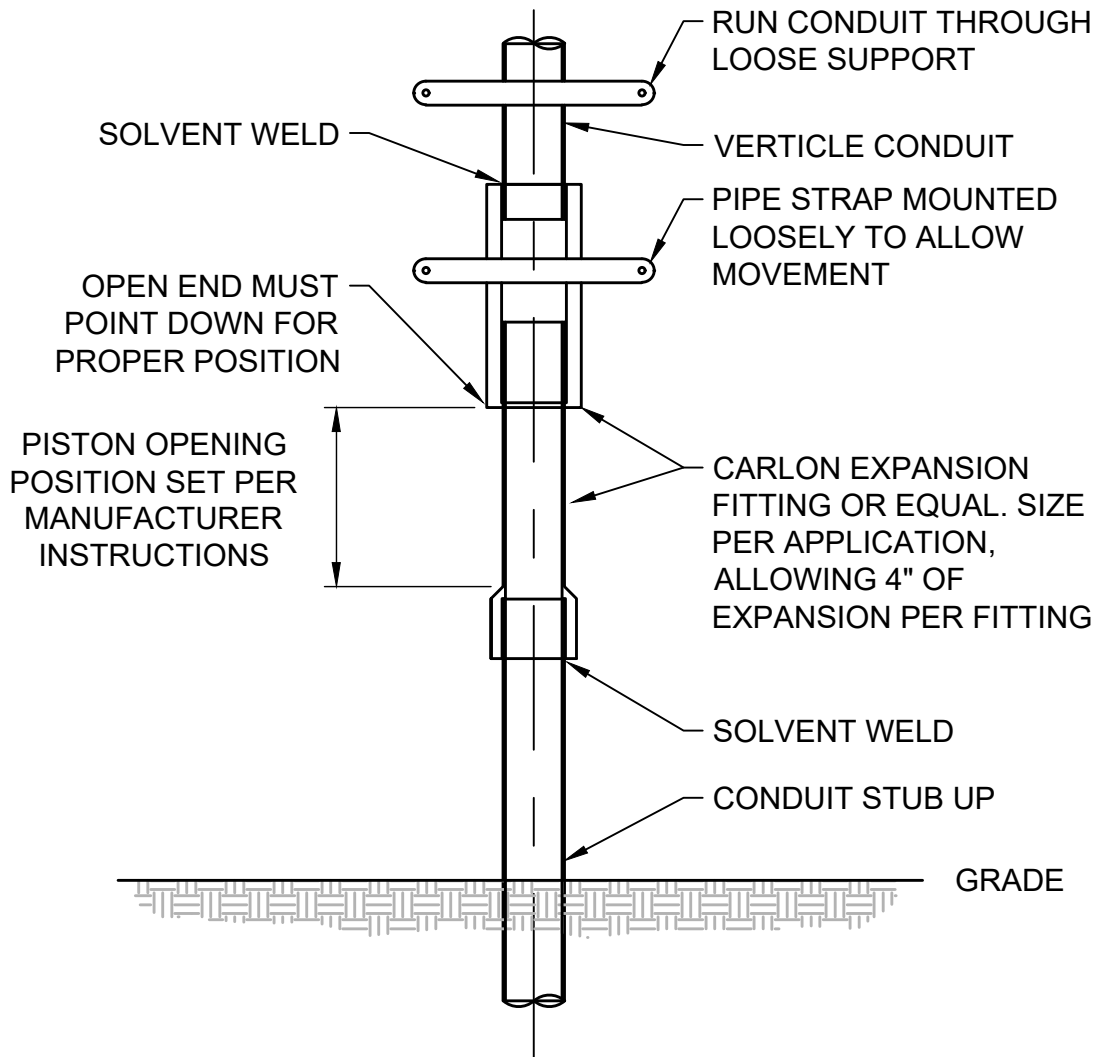
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EXPANSION DEFLECTION DETAIL

STANDARD DRAWING NO.

E15



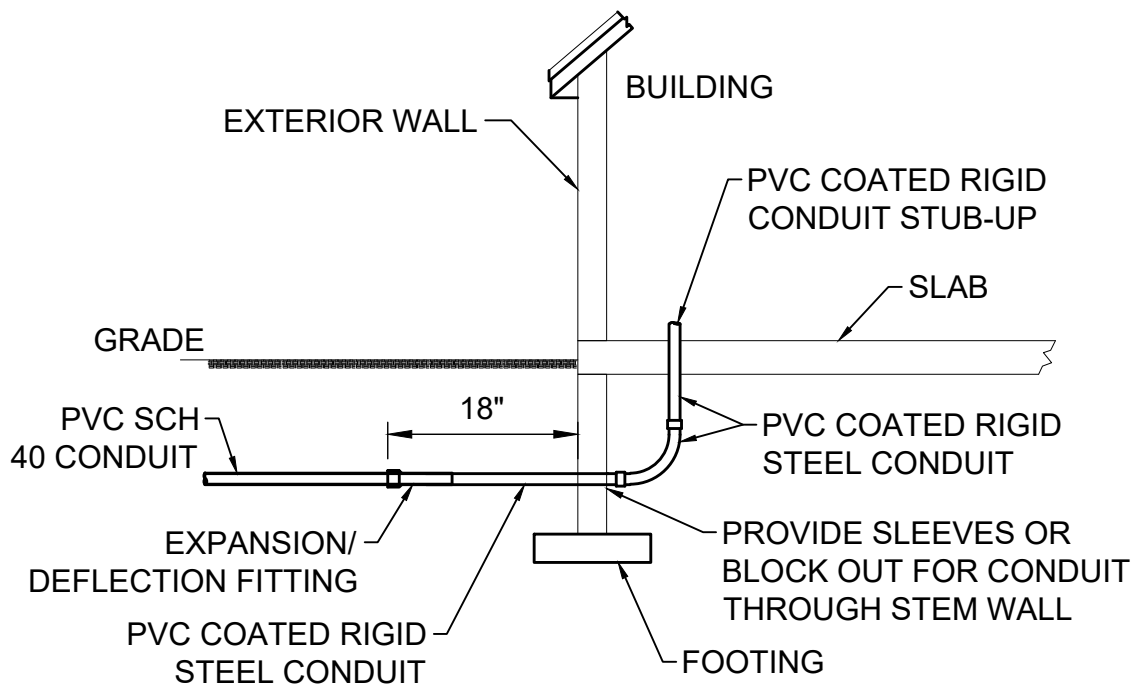
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CITY OF MERIDIAN
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EXPANSION FITTING DETAIL WITH MIN
 4" OF MOVEMENT IN VERTICAL
 CONDUIT

STANDARD DRAWING NO.

E16



NOTES:

1. PROVIDE EXPANSION/DEFLECTION FITTINGS IN RACEWAY RUNS THAT EXIT BUILDING OR STRUCTURE BELOW SLAB.
2. LOCATE FITTING 18 INCHES, MAXIMUM, BEYOND EXTERIOR WALL.
3. RACEWAY TYPE BETWEEN BUILDING EXTERIOR WALL TO FITTING SHALL BE PVC-COATED RIGID STEEL.
4. ALL EXPANSION/DEFLECTION FITTINGS SHALL BE INSPECTED AND APPROVED BY ENGINEER PRIOR TO BACKFILL.

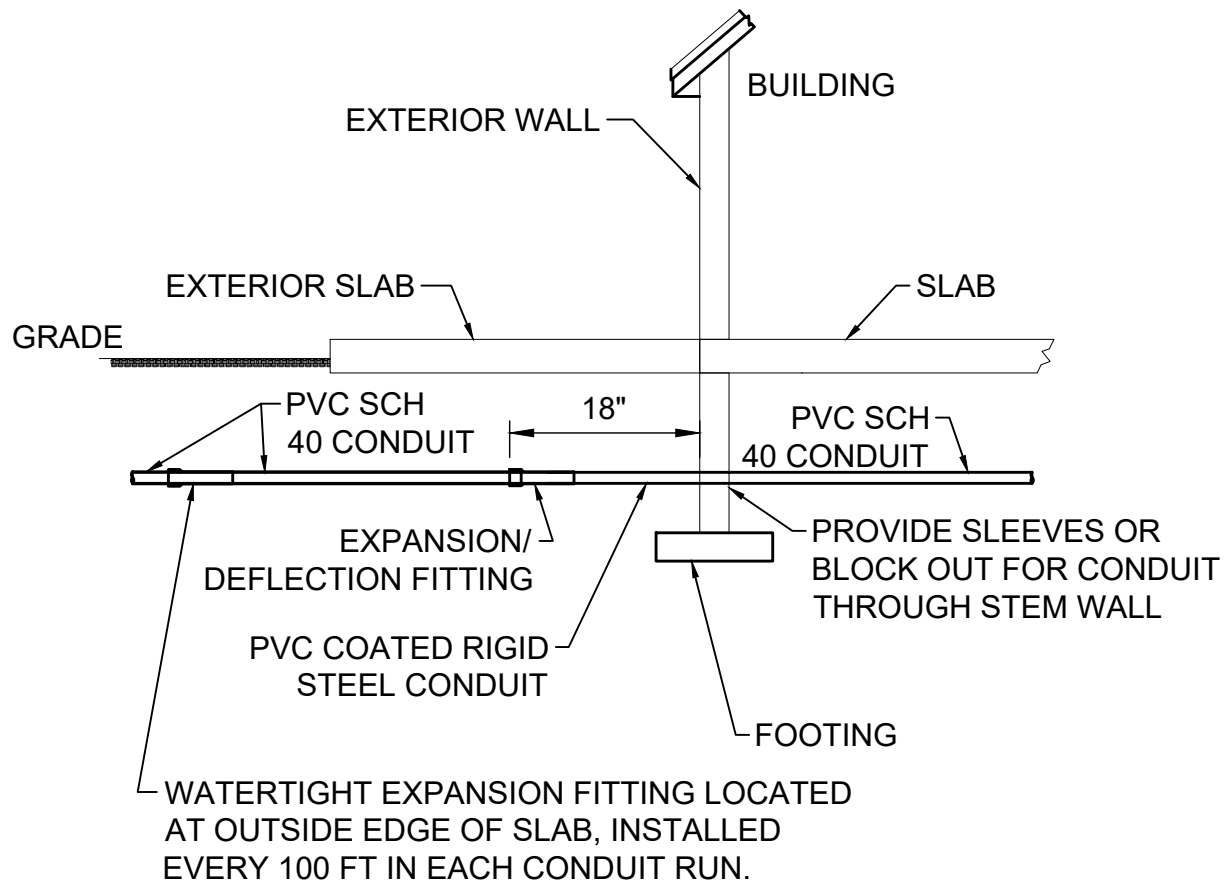
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CITY OF MERIDIAN
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TO THE IDAHO STANDARDS FOR
PUBLIC WORKS CONSTRUCTION

**EXPANSION/DEFLECTION FITTING
IN CONDUIT THAT EXIT
BUILDING/STRUCTURE**

STANDARD DRAWING NO.

E17



NOTES:

1. PROVIDE EXPANSION/DEFLECTION FITTINGS IN RACEWAY RUNS THAT EXIT BUILDING OR STRUCTURE BELOW SLAB.
2. LOCATE FITTING 18 INCHES, MAXIMUM, BEYOND EXTERIOR WALL.
3. RACEWAY TYPE BETWEEN BUILDING EXTERIOR WALL TO FITTING SHALL BE PVC-COATED RIGID STEEL.
4. ALL EXPANSION/DEFLECTION FITTINGS SHALL BE INSPECTED AND APPROVED BY ENGINEER PRIOR TO BACKFILL.

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CITY OF MERIDIAN
SUPPLEMENTAL
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PUBLIC WORKS CONSTRUCTION

**EXPANSION/DEFLECTION FITTING
IN RACEWAY RUNS THAT EXIT
BELOW SLAB**

STANDARD DRAWING NO.

E18