

## SECTION 16100

## BASIC MATERIALS AND METHODS - INTERIOR

## PART 1 - GENERAL

## 1.01 RELATED DOCUMENTS

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

## 1.02 WORK INCLUDED

- A. The work covered by this Section of the Specifications includes the furnishing of all plant, labor, equipment, appliances and materials, and in performing all operations in connection with providing and installing the interior electrical work, complete, in strict accordance with this Section of the Specifications and the applicable drawings and subject to the terms and conditions of the Contract.

## 1.03 RELATED WORK

- A. Applicable requirements of other Sections of Division 16 shall apply to this Section.

## 1.04 SUBMITTALS

- A. Submit under provisions of Division 1.
- B. Shop Drawings: Submit on equipment specially manufactured or modified for this project.
- C. Submit product data for:
  - 1. Raceways, fittings and boxes.
  - 2. Wire and cable.
  - 3. Splicing materials.
  - 4. Dry-type transformer.
  - 5. Grounding equipment.

## 1.05 PROJECT RECORD DOCUMENTS

- A. Submit record documents under provisions in Division 1.
- B. Accurately record actual locations of equipment.

## PART 2 - PRODUCTS

## 2.01 RACEWAY SYSTEMS

- A. Conductors shall be installed in raceways as specified. Raceways shall be sized as indicated in accordance with the National Electrical Code requirements and shall bear the label of the Underwriters Laboratories, Incorporated. Raceways shall include rigid steel-threaded conduit, liquidtight metallic flexible conduit, non-metallic PVC conduit.
- B. Rigid threaded steel conduit shall be hot dip galvanized as manufactured by the Wheatland Tube Co., Republic Steel, Allied Tube or an approved equal. Rigid steel conduits shall conform to Federal Specification WW-C-581d. Minimum size shall be 3/4-inch.
- C. Non-metallic conduits shall be heavy wall rigid polyvinyl chloride schedule 40 PVC pipe, Type II for direct burial and shall be laid in trench as indicated. The conduit shall conform to UL Standard 651, NEMA TC2-1978 and Federal Specification WC-1094 A and shall be Carlon Plus 40 or approved equal.
- D. Liquidtight flexible metallic conduit shall be UL Listed Type LA "Liquidtite" manufactured by Electri-flex Company or approved equal.
- E. Wireways shall be complete with necessary fittings accessories, covers and connectors and shall be hot dipped galvanized finished or nonmetallic NEMA 4X construction. The wireways shall be of the code size required with hinged cover and separation of high and low voltage systems, and shall bear the Underwriters' Laboratories label. Wireways shall be securely supported by approved methods. The wireways and fittings shall be approved for the location and environment where it is installed. Where physical damage could be expected, provide metallic wireway approved for the purpose.

## 2.02 BOXES

- A. Outlet boxes for indoor locations shall be pressed steel, zinc coated and provided with proper sized knockouts, as manufactured by Raco, Steel City or approved equal.
- B. Outlet boxes for exterior locations shall be FS type cast-metal with threaded hubs and lugs, as manufactured by Crouse-Hinds, Appleton or approved equal.
- C. Pull boxes shall be sufficiently rigid to withstand moderate twisting strains. Steel boxes of 100 cubic inches or less shall be No. 14 USS gage; between 101 and 8500 cubic inches shall be No. 12 USS gage; larger boxes shall be No. 10 USS gage and shall be manufactured by McKinstry, Hoffman, Barber or approved equal.
- D. Boxes shall be of adequate size to accommodate the installation of conductors without excessive bending of the conductor which would damage the insulation. Maximum number of conductors in a box shall comply with NEC.
- E. Steel boxes other than wiring device outlet boxes, unless otherwise specified herein or shown on the drawings, shall be NEMA 1 gasketed construction with a hot-dipped galvanized finish for interior locations; and NEMA 4X construction, either metallic or non-metallic (fiberglass), for exterior locations.

- F. Boxes shall be furnished with a grounding terminal having a slotted Hexagonal head washer face ground screw with green finish for ground termination.

### 2.03 FITTINGS

- A. Rigid steel conduit fittings shall be of the malleable iron threaded type. Die cast fittings, threadless connectors and split-threaded connectors shall not be acceptable. Fittings shall be as manufactured by Crouse-Hinds, Killark, Appleton Companies or an approved equal.
- B. Non-metallic PVC fittings, adapters and cement shall be of the same manufacturer.
- C. Liquidtight flexible metallic conduit fittings shall be insulated throat, steel or malleable iron zinc plated, as manufactured by OZ Gedney, T&B or Appleton. Die cast fittings shall not be acceptable.
- D. All supports, clamps and anchors shall be galvanized steel, malleable iron or stainless steel.

### 2.04 WIRE AND CABLE

- A. Wire and cable of the sizes, wire numbers and types, sized in accordance with the National Electrical Code, shall be provided by the Contractor.
- B. All wire and cable work shall be in strict accordance with the requirements of the National Electrical Code and its latest revisions, both with respect to material and workmanship, except where insulation thickness and covering are required by these Specifications in excess of Code requirements.
- C. Wire shall be copper, type "THWN/THHN" with insulation thickness for 600 volts in accordance with the National Electrical Code with dual rating of 75°C/90°F, for dry and wet locations. Wire sizes No. 6 AWG or larger, shall be copper, type "XHHW" with insulation thickness for 600 volts with dual rating of 75°C/90°F for dry and wet locations. Insulation shall be cross-linked polyethylene (XLP) rated for 600 volts.
- D. Wire and cables shall be single conductor except where otherwise specified or indicated on the Drawings. Conductors of sizes No. 6 AWG and larger shall be stranded. Wires of sizes smaller than No. 8 AWG shall be solid.
- E. Conductors shall be soft-drawn copper and have a conductivity of not less than 98 percent of ASTM standards for annealed copper.
- F. Wires and cables shall be as manufactured by the American Insulated Wire Corp. or an approved equal.
- G. Cable lubricant shall be used where necessary when pulling wire or cable and shall be U.L. listed. Cable lubricant shall be as manufactured by Ideal Products, American Polywater or an approved equal.

### 2.05 GUTTER WIRING

- A. Gutter wiring in switches and such other equipment shall be neatly formed and tied with cable ties and straps. The ties and straps shall be Burndy, Thomas & Betts Company, or an approved equal.

## 2.06 COLOR CODING

- A. Wires and cables shall be factory color-coded with a separate color for each phase and neutral used consistently throughout the power and lighting systems. The neutral (grounded) wire of branch circuits shall have a white covering and connections to single pole switches shall be so made that the operation of the switch opens the ungrounded conductor. Color-coding shall be as follows:

120/208 Volts, 3 Phase, 4 Wire

Phase A – Black  
Phase B – Red  
Phase C – Blue  
Neutral – White  
Grounding – Green

480Y/277 Volts, 3 Phase, 4 Wire

Phase A – Brown  
Phase B – Orange  
Phase C – Yellow  
Neutral – White or Grey  
Grounding – Green

- B. Sizes AWG #8 and larger may be taped for color coding, providing all exposed cables outside of raceways be completely color taped or printed in accordance with IPCEA S-19-81 Method 3.

## 2.07 SPLICES AND TAPS

- A. Connections between wires No. 8 AWG and smaller shall be wing-skirted, live-spring-type connectors (wire nuts), as manufactured by Ideal, 3M and T&B.
- B. Splices, taps and terminations in wires No. 6 and larger shall be made with Compression type "Color Keyed" as manufactured by Burndy, Sta-Kon, Thomas and Betts Company or an approved equal, solderless pressure connectors designed for the purpose.
- C. Splices and taps shall be covered with heat shrinkable tubing. The tubing shall be rated and UL listed to 600 volts, 90°C. The tubing shall be precoated with thermoplastic adhesive-sealant able to adhere to all common wire insulating materials including XLPE, PVC, neoprene, hypalon and EPR, lead, aluminum and steel. The tubing shall be manufactured by Raychem Type WCSM or approved equal.

## 2.08 NAMEPLATES AND INDEXING

- A. Equipment not normally supplied with directory frames as indicated, whether supplied under this section or other sections of these specifications, and at the request of the Engineer shall be provided with dark engraved bakelite nameplates with engraving through to white core. Nameplate markings shall be approved by the Owner. Only a part of the required nameplates are indicated. Nameplates on boxes shall supplement painting specified hereinafter.
- B. Engraved bakelite nameplates with engraving through to a white core shall be provided. Nameplates shall be provided on the following equipment, as well as electrical equipment.
  - 1. Panelboards.
  - 2. Disconnect switches remote from equipment.
- C. Nameplates shall be secured with a minimum of two suitable screws.
- D. Nameplates for equipment 120 volts and above shall indicate voltage.
- E. Circuit directories – Provide and complete new circuit directories for all existing panelboards based on field survey by the Contractor.

## 2.09 DRY-TYPE TRANSFORMERS

- A. Provide transformers rated as required or indicated on the drawings.
- B. Three phase transformers shall be rated as indicated and required for the project. Transformers shall have a minimum of (2) - 2½% full capacity primary taps above and below rated voltage.
- C. Transformers shall be 115°C temperature rise above 40°C ambient. All insulating materials to be in accordance with NEMA ST20 standards for a 220°C UL component recognized insulation system. The transformer shall be UL listed for specific temperature rise.
- D. Transformer coils shall be of the continuous wound construction and shall be impregnated with nonhygroscopic, thermosetting varnish.
- E. All cores to be constructed of high grade, non-aging silicon steel with high magnetic permeability, and low hysteresis and eddy current losses. Magnetic flux densities are to be kept well below the saturation point. The core laminations shall be clamped together with structural steel angles. The completed core and coil shall then be bolted to the base of the enclosure but isolated by means of rubber, vibration absorbing mounts. There shall not be metal-to-metal contact between the core and coil and the enclosure. The vibration isolating system shall be designed to provide a permanent fastening of the core and coil to the enclosure. Sound isolating systems requiring the complete removal of all fastening devices will not be acceptable.
- F. Transformers shall be in a heavy gauge, sheet steel, ventilated enclosure. The ventilating openings shall be designed to prevent accidental access to live parts in accordance with UL, NEMA, and National Electrical Code standards for ventilated

enclosures. Transformers through 75 KVA shall be designed so they can be wall-mounted.

- G. The entire transformer enclosure shall be degreased, cleaned, phosphatized, primed, and finished with a grey, baked enamel.
- H. The maximum temperature of the top of the enclosure shall not exceed 35 degree C rise above a 40 degree C ambient.
- I. The core of the transformer shall be visibly grounded to the enclosure by means of a flexible grounding conductor sized in accordance with applicable NEMA, IEEE, and ANSI standards.
- J. Sound levels shall not exceed NEMA standards.
- K. Transformers shall be as manufactured by ACME, General Electric, Square D or Westinghouse/Cutler-Hammer.

#### 2.10 DISCONNECT SWITCHES

- A. Disconnecting devices, when not included with electrically operated equipment furnished under other Sections, shall be furnished and installed under this Section. Disconnects shall be heavy-duty NEMA Type HD and UL listed. General duty disconnect switches will not be accepted. Disconnecting devices shall be manufactured by Square D, General Electric or Westinghouse/Cutler-Hammer.
- B. Electrical characteristics of disconnects including voltage class, ampere rating, number of poles and NEMA enclosure type shall be as shown on the drawings or specified herein. Disconnects shall be 3-pole in general purpose NEMA 1 enclosure unless otherwise indicated. NEMA 4X disconnects shall be used for all wet or exterior locations.
- C. The external operating handle shall be mechanically interlocked with the enclosure cover. The interlock shall make it necessary for the disconnect to be in the "OFF" position for normal access to the inside of the enclosure. A means for bypassing the mechanically interlocked cover and handle shall be provided.
- D. Enclosure shall have provisions for locking the operating handle in the "OPEN" position. Position of disconnect shall be clearly indicated on the enclosure.

#### 2.11 LIGHTING FIXTURES

- A. Lighting fixtures and equipment of the exact type and quality specified and indicated on the Drawings shall be provided in order to achieve the quality and levels of illumination incorporated in the lighting design. It will be understood that lighting fixtures and equipment will be furnished in strict accordance with the Specifications or as indicated.
- B. Provide lighting fixtures, lighting equipment and components complete, including canopies, suspension of proper lengths, hickeyes, casings, sockets, holders, reflectors and such other incidental items, all wired and assembled. Fixtures shall be lamped as indicated on the Drawings.

- C. Ballasts shall be as manufactured by General Electric, Advance, Universal, or approved equal to meet NEC Section 410-73(e) and Specification LP 715. Ballast types, accessories and options shall be as indicated on the Drawings.
- D. Lamp life shall be not less than the following with a minimum of 3 hours per start.
1. Fluorescent - Type F48T8/HO lamp - 20,000 hours.
  2. Compact fluorescent – 10,000 hours.

## 2.12 LIGHTING SWITCHES

- A. Switches shall meet the requirements of Federal Specification W5896E and be UL-listed. Switches shall be totally enclosed with a thermoset body, have a steel mounting strap and a one-piece contact arm. Switches shall be back- and side-wired and rated for 20 amperes at 120/277 volts, with a separate screw terminal for the grounding wire.

Lighting switches shall be as follows:

Device <u>Type</u>	Leviton <u>Cat. No.</u>	GE <u>Cat. No.</u>	Hubbell <u>Cat. No.</u>
Single Pole	1221	5951-1G	1221

## 2.13 GROUNDING

- A. Ground connectors shall be clamp style, as required by the design. Bolts, nuts and washers and other components of the connectors shall assure a permanent corrosion-resistant assembly. Connectors shall be as manufactured by Thomas & Betts Corp.; Cadweld by Erico Products Company, or an approved equal.

## PART 3 - EXECUTION

### 3.01 CONDUIT INSTALLATION

- A. Installation shall be in accordance with U.L., National Electrical Code (N.E.C.) and specified herein.
- B. Route conduit parallel and perpendicular to walls and adjacent piping and do not obstruct headrooms, walkways or hatchways.
- C. Conduit shall be supported and clamped using hardware intended for the purpose.
- D. Conduit bends shall be made with standard conduit bendings tools. Conduit deformed or flattened during bending shall be removed and replace.
- E. Conduits cut in the field shall be coated with galvanized hot stick or galvanized spray approved for the purpose.
- F. Supports shall be provided every 5 feet for conduits wherever possible, and within 3 feet of outlets, boxes or fittings, the points of support to be determined in the field. The supports shall consist of approved types of clamps or straps secured by screws, bolts on wood or steel framework and decking, or expansion bolts in concrete. In no

instance shall supporting bolts or screws protrude to the outside of building walls or roof.

- G. The metal raceway systems shall become metallically continuous throughout its entire length and the entire system shall be electrically continuous and shall be thoroughly grounded in accordance with the N.E.C.
- H. Conduit penetrations from outside walls to interior spaces shall be sealed in an approved conduit sealing system.

### 3.02 CONDUIT INSTALLATION SCHEDULE

- A. Rigid Steel Conduit: Exposed exterior or interior locations, where subjected to physical damage or wet/damp locations; where penetrating through concrete slabs.
- B. Non Metallic PVC Conduit: Underground and where not subjected to direct physical damage.
- C. Liquidtight flexible metallic conduit shall be installed as final connections to motors, transformers and equipment in damp or wet locations; and shall not exceed 18 inches in length. Grounding shall be metallically continuous in accordance with the requirements of the National Electrical Code.

### 3.03 WIRE AND CABLE INSTALLATION

- A. Install in accordance with NEC, in raceway systems.
- B. Lubricants for assisting in the pulling of jacketed cables shall be those specifically recommended by the cable manufacturer. Cable lubricants shall be soapstone, graphite, or talc for rubber or plastic jacketed cables. The lubricant shall not be deleterious to the cable sheath, jacket, or outer coverings.
- C. Cable pulling tension shall not exceed the maximum pulling tension recommended by the cable manufacturer.
- D. Provide an insulated copper equipment-grounding conductor with every branch circuit and feeder sized in accordance with the National Electric Code Conductors No. 6 AWG and larger may be bare copper conductor.
- E. Wires and cables shall be carefully handled during storage and installation to avoid mechanical injury to the conductor, insulation or covering. Use non-metallic pulling ropes or cords. Attach pulling lines to wires with woven basket grips or pulling eyes. Pull all wires together in single conduits.
- F. Use solderless pressure connectors with insulating covers for copper wire splices and taps, 8 AWG and smaller. For 10 AWG and smaller, use insulated spring wire connectors with plastic caps. Compression-type connectors for copper wire splices and taps, 6 AWG and larger.
- G. Thoroughly clean wires before installing lugs and connectors.



- H. Make splices, taps and terminations to carry full ampacity of conductors without perceptible temperature rise.
- I. Tape uninsulated conductors and connectors with electrical tape to 150 percent of the insulation value of conductor. Heat shrinkage tubing, approved for the purpose, may be used in lieu of tape splices.
- J. Terminate spare conductors with electrical tape or heat shrinkable tubing.
- K. For panelboards, cabinets, wireway, switches and equipment assemblies neatly form, train, and tie the cables in individual circuits.

### 3.04 BOXES AND ENCLOSURE INSTALLATION

- A. Provide electrical boxes as required for splices, taps, wire pulling, equipment connections, and code compliance.
- B. Boxes shall be secured to conduit by means of conduit hubs if hubs are not integral to the box.
- C. Verify location of boxes and outlets prior to rough-in. Locate and install boxes above accessible ceiling or in unfinished areas. Where installation is inaccessible, call it to the attention of the Engineer/Owner before relocating the box location.
- D. Support boxes independently of conduit except for cast boxes that are connected to two rigid metal conduits, both supported within 12 inches of boxes.

### 3.05 EQUIPMENT WIRING

- A. Verify that equipment is ready for electrical connection, wiring, and energization.
- B. Review equipment submittals prior to installation and electrical rough-in. Verify location, size, and type of connections. Coordinate details of equipment connections with supplier and installer.
- C. Grounding shall be metallically continuous in accordance with the requirements of the National Electric Code.
- D. Make wiring connections in accordance with manufacturer's instructions. All connections shall be tightened to the manufacturer's recommended torque settings utilizing a torque wrench.

### 3.06 GROUNDING

- A. Bond to the electrical single point service ground bus at the service entrance equipment and reconnect to bond building steel, water piping and supplementary grounding electrode.
- B. Metallic conduit, supports, transformers, breakers, cabinets and equipment shall be grounded in accordance with the latest issue of the National Electrical Code and as indicated.

- C. The grounding system shall be tested for a resistance not greater than 25 ohms and shall be measured prior to placing equipment in operation in accordance with N.E.C., as approved by authority having jurisdiction.

### 3.07 SUPPORT AND ANCHORS

- A. Review equipment submittals prior to installation of equipment. Exercise judgment when supporting equipment. If support methods are questionable or not available, call it to the attention of the Owner prior to installation.
- B. Fasten hanger rods, conduit clamps, and outlet and junction boxes to building structure using expansion anchors, beam clamps, galvanized steel clips. All areas shall be considered as moist, humid atmosphere and materials shall be provided for this condition.
- C. Use sheet metal screws in sheetmetal studs and wood screws in wood construction.
- D. Do not fasten supports to conduit.

### 3.08 ACCEPTANCE TESTS

- A. Upon completion of electrical equipment installation and prior to energization, perform acceptance tests on electrical equipment in accordance with NETA Std. ATS, 1995, or the approved test plan.
- B. Submit test results for review.
- C. Upon completion of acceptance tests, verify circuits indicated on panel schedules and correct circuit data indicated on the schedule and provide updated panel directories. As a minimum, circuit data shall indicate active circuits and spare circuits and panel space.

END OF SECTION 16100